



THE COAST AND GEODETIC
SURVEY

ITS HISTORY, ACTIVITIES
AND ORGANIZATION

THE INSTITUTE FOR GOVERNMENT RESEARCH

Washington, D. C.

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INSTITUTE FOR GOVERNMENT RESEARCH

SERVICE MONOGRAPHS
OF THE
UNITED STATES GOVERNMENT
No. 16

THE COAST AND GEODETIC SURVEY
ITS HISTORY, ACTIVITIES
AND ORGANIZATION

BY
GUSTAVUS A. WEBER

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FOREWORD

The first essential to efficient administration of any enterprise is full knowledge of its present make-up and operation. Without full and complete information before them, as to existing organization, personnel, plant, and methods of operation and control, neither legislators nor administrators can properly perform their functions.

The greater the work, the more varied the activities engaged in, and the more complex the organization employed, the more imperative becomes the necessity that this information shall be available—and available in such a form that it can readily be utilized.

Of all undertakings, none in the United States, and few, if any, in the world, approach in magnitude, complexity, and importance that of the national government of the United States. As President Taft expressed it in his message to Congress of January 17, 1912, in referring to the inquiry being made under his direction into the efficiency and economy of the methods of prosecuting public business, the activities of the national government “are almost as varied as those of the entire business world. The operations of the government affect the interest of every person living within the jurisdiction of the United States. Its organization embraces stations and centers of work located in every city and in many local subdivisions of the country. Its gross expenditures amount to billions annually. Including the personnel of the military and naval establishments, more than half a million persons are required to do the work imposed by law upon the executive branch of the government.

“This vast organization has never been studied in detail as one piece of administrative mechanism. Never have the foundations been laid for a thorough consideration of the relations of all of its parts. No comprehensive effort has been made to list its multifarious activities or to group them in such a way as to present a clear picture of what the government is doing. Never has a complete description been given of the agencies through which these activi-

ties are performed. At no time has the attempt been made to study all of these activities and agencies with a view to the assignment of each activity to the agency best fitted for its performance, to the avoidance of duplication of plant and work, to the integration of all administrative agencies of the government, so far as may be practicable, into a unified organization for the most effective and economical dispatch of public business."

To lay the basis for such a comprehensive study of the organization and operations of the national government as President Taft outlined, the Institute for Government Research has undertaken the preparation of a series of monographs, of which the present study is one, giving a detailed description of each of the fifty or more distinct services of the government. These studies are being vigorously prosecuted, and it is hoped that all services of the government will be covered in a comparatively brief space of time. Thereafter, revisions of the monographs will be made from time to time as need arises, to the end that they may, as far as practicable, represent current conditions.

These monographs are all prepared according to a uniform plan. They give: first, the history of the establishment and development of the service; second, its functions, described not in general terms, but by detailing its specific activities; third, its organization for the handling of these activities; fourth, the character of its plant; fifth, a compilation of, or reference to, the laws and regulations governing its operations; sixth, financial statements showing its appropriations, expenditures and other data for a period of years; and finally, a full bibliography of the sources of information, official and private, bearing on the service and its operations.

In the preparation of these monographs the Institute has kept steadily in mind the aim to produce documents that will be of direct value and assistance in the administration of public affairs. To executive officials they offer valuable tools of administration. Through them, such officers can, with a minimum of effort, inform themselves regarding the details, not only of their own services, but of others with whose facilities, activities, and methods it is desirable that they should be familiar. Under present conditions services frequently engage in activities in ignorance of the fact that the work projected has already been done, or is in process of execution by other services. Many cases exist where one service could

make effective use of the organization, plant or results of other services had they knowledge that such facilities were in existence. With the constant shifting of directing personnel that takes place in the administrative branch of the national government, the existence of means by which incoming officials may thus readily secure information regarding their own and other services is a matter of great importance.

To members of Congress the monograph should prove of no less value. At present these officials are called upon to legislate and appropriate money for services concerning whose needs and real problems they can secure but imperfect information. That the possession by each member of a set of monographs such as is here projected, prepared according to a uniform plan, will be a great aid to intelligent legislation and appropriation of funds can hardly be questioned.

To the public, finally, these monographs will give that knowledge of the organization and operations of their government which must be had if an enlightened public opinion is to be brought to bear upon the conduct of governmental affairs.

These studies are wholly descriptive in character. No attempt is made in them to subject the conditions described to criticism, nor to indicate features in respect to which changes might with advantage be made. Upon administrators themselves falls responsibility for making or proposing changes which will result in the improvement of methods of administration. The primary aim of outside agencies should be to emphasize this responsibility and facilitate its fulfillment.

While the monographs thus make no direct recommendations for improvement, they cannot fail greatly to stimulate efforts in that direction. Prepared as they are according to a uniform plan, and setting forth as they do the activities, plant, organization, personnel and laws governing the several services of the government, they will automatically, as it were, reveal, for example, the extent to which work in the same field is being performed by different services, and thus furnish the information that is essential to a consideration of the great question of the better distribution and coördination of activities among the several departments, establishments, and bureaus, and the elimination of duplications of plant, organization and work. Through them it will also be possible to

subject any particular feature of the administrative work of the government to exhaustive study, to determine, for example, what facilities, in the way of laboratories and other plant and equipment, exist for the prosecution of any line of work and where those facilities are located; or what work is being done in any field of administration or research, such as the promotion, protection and regulation of the maritime interests of the country, the planning and execution of works of an engineering character, or the collection, compilation and publication of statistical data, or what differences of practice prevail in respect to organization, classification, appointment, and promotion of personnel.

To recapitulate, the monographs will serve the double purpose of furnishing an essential tool for efficient legislation, administration and popular control, and of laying the basis for critical and constructive work on the part of those upon whom responsibility for such work primarily rests.

Whenever possible the language of official statements or reports has been employed, and it has not been practicable in all cases to make specific indication of the language so quoted.

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THE COAST AND GEODETIC SURVEY ITS HISTORY, ACTIVITIES, AND ORGANIZATION

CHAPTER I

HISTORY

The functions of the Coast and Geodetic Survey of the Department of Commerce comprise hydrographic and topographic surveys of the coasts of the United States and of coasts under its jurisdiction, and of rivers to the head of tide-water or ship navigation, and the publication of charts of the same; the determination of heights and geographic positions to furnish control points for surveys; and observation and research work in terrestrial magnetism, tides and currents and gravity.

The first suggestion of a systematic government survey of the American coasts was probably made by Dr. Robert Patterson of Philadelphia, who brought the matter to the attention of President Jefferson and some members of his cabinet.

In 1806 the President made a recommendation for a coast survey to Congress, which took favorable action, and on February 10, 1807, an act (2 Stat. L., 413), was approved authorizing the President to cause a survey to be made of the coasts of the United States, in which were to be designated "the islands and shoals with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes or headlands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts." It also authorized a survey to be made of St. Georges bank and any other banks or shoals, and the soundings and currents beyond the above mentioned limits to the Gulf Stream.

Early Action for a Coast Survey. The work of carrying out the provisions of this act was entrusted by the President to the

Secretary of the Treasury. The latter, with the approval of the President, issued a circular setting forth a project of a survey, inviting the attention of scientists to it, and requesting plans for carrying it into effect.

In this project the proposed operations were to consist of: (1) The ascertainment, by a series of astronomical observations, of the true positions of a few remarkable points on the coast; (2) a trigonometrical survey of the coast between these points; and (3) a nautical survey of the shoals and soundings of the coast, of which the trigonometrical survey was to supply the basis.

Among the persons who responded to the invitation of the Secretary of the Treasury was F. R. Hassler, a Swiss engineer of considerable experience in practical triangulation work, at that time instructor of mathematics at West Point. Hassler's submitted plan was adopted, and he was appointed as the first superintendent of the "Survey of the Coast."

Owing to the absence of the necessary instruments and other facilities, no work was undertaken at once, but on July 27, 1811, Hassler was engaged to proceed to Europe to procure the necessary instruments, many of which had to be specially made. He was detained there by the War of 1812 and by other causes until 1815.

Creation of the Survey. On August 3, 1816, Hassler received a definite appointment in the Treasury Department as "Superintendent of Survey of the Coast," his compensation under this appointment dating from June 18, 1816, which is regarded as the date of the creation of the survey of the coast.

In 1816 a commencement of the coast survey was definitely made in the bay and harbor of New York. The work had barely begun when it had to be suspended in consequence of the failure of Congress to provide funds for its continuance.

Transfer of the Work to the Navy Department. The act of 1807 had given the President authority "to cause proper and intelligent persons to be employed," and the President had chosen to place the survey under civilian supervision in the Treasury Department. On April 14, 1818 (3 Stat. L., 425), however, so much of the act "as authorized the employment of other persons

in the execution of said act, than by persons belonging to the army and navy" was repealed.

The effect of this act was to cause a suspension, on April 29, 1818, of the systematic coast survey work that had been planned and begun by Hassler. The Survey ceased to exist as a separate organization and the work and instruments were turned over to the Navy Department.

In 1818 and for several years thereafter, the Superintendent of the Survey participated, with a number of army officers, in making the boundary surveys required under the treaty of Ghent along the northern boundaries of New York, Vermont, New Hampshire, and Maine.

During the period from April 30, 1818 to July 9, 1832, some detached surveys of rivers and harbors and hydrographic reconnaissances of the coast were made by the Navy Department for naval purposes and by officers of the engineer corps of the army under special acts of Congress for specific localities, but no general or connected survey of the coast was attempted during this period.

Transfer of the Work to the Treasury Department. In 1828, the Secretary of the Navy, in reply to a resolution of inquiry from the Committee on Naval Affairs of the House of Representatives, recommended a revival of the act of 1807 and, after subsequent repeated recommendations of the Secretary of the Navy and petitions from other sources, Congress, by an act of July 10, 1832 (4 Stat. L., 571), revived the act of 1807, giving the survey work a somewhat more extended scope, making a small appropriation, and authorizing the President to employ in the conduct of the work such astronomers and other persons as he should judge proper in addition to officers in the land and naval services. The service was again placed by the President in the Treasury Department, where a bureau was established, and Hassler, the original Superintendent of the Survey, was reappointed.

Service of Weights and Measures. At this time, Hassler was engaged in the Treasury Department comparing the weights and measures to be used at the custom houses of the United States and ascertaining by experiment the proper hydrometer proofs of liquor. This work was continued under his charge and became one of the

functions of the Coast Survey, this division being known as the Office of Standard Weights and Measures. By an act approved March 3, 1901 (31 Stat. L., 1449), this office became a part of the National Bureau of Standards, which began operations on July 1, 1901.

Further Transfers. Scarcely had the operations of the survey been fairly resumed under the Treasury Department, when President Jackson, upon the recommendation of the Secretary of the Treasury, on March 11, 1834, directed that the Survey be retransferred to the control of the Navy Department. Again the work proceeded so unsatisfactorily in that department that within about two years, that is, on March 27, 1836, the survey was returned by order of President Jackson to the Treasury Department.

Up to this time the service had been designated the "Survey of the Coast," but in 1836 the title was changed to "Coast Survey."

Development Under Early Organization. From 1836 to 1843 the Coast Survey was permitted to carry on its work in the Treasury Department without disturbance or interruption by Congress or by the President. During the incumbency of Hassler the Coast Survey grew from a small beginning until, in 1843, its work comprehended various operations of a geodetic survey on the land and the hydrography of the adjacent waters. The first years of its existence were necessarily spent in organization and instruction. The work had to be planned and systematized. Assistants had to be trained. When the results of the field operations accumulated, provision had to be made for compilations and reductions and for the preparation of maps and charts.

In 1843 a base line had been measured on the south side of Long Island in the vicinity of New York. The triangulation had extended eastward to Rhode Island, and southward to the head of Chesapeake Bay, the primary triangulation crossing the neck of New Jersey and Delaware, while the secondary triangulation skirted the coast of New Jersey, meeting with another series which extended down Delaware Bay. The topographical work had kept pace with the triangulation, and the hydrography of New York Bay and harbor, of Long Island Sound, of Delaware Bay and river, and the off-shore work from Montauk Point to the capes of the Delaware were nearly completed. The triangulation had

covered an area of 9000 square miles, furnishing determinations of nearly 1200 stations for the delineation of 1600 miles of shore line; 168 topographical sheets had been surveyed, and 142 hydrographic charts prepared.

Congressional Investigation of the Survey, 1842. Notwithstanding this extraordinary accomplishment under the difficulties that had been placed in the way of the Coast Survey, clamors arose in Congress against the administration of that bureau. Dissatisfaction was expressed with the progress made. The alleged slow progress was ascribed to an unnecessary refinement in the process employed. The results were claimed to be inadequate to the expenditures. The old agitation for a transfer to the Navy Department was revived.

As a result of this clamor, an investigation of the Coast Survey was instituted in 1842 by a congressional committee, which after a severe and unfriendly scrutiny by the members, resulted in a complete endorsement of the principles on which the survey had been conducted by Hassler.

Adoption of Permanent Plan of Organization. The following year Congress, by an act approved March 3, 1843 (5 Stat. L., 640), called for a permanent plan of organization of the Coast Survey, to be made by a board consisting of the superintendent, his two principal assistants, the two naval officers then in charge of the hydrographic parties, and four members chosen from among the principal officers of the corps of topographical engineers.

A plan was adopted by this board on March 30, 1843. It outlined the character and methods of work to be pursued by the Coast Survey, and defined the form of organization and the duties of its officers and employees. In proposing this plan the board laid the foundation for the extensive system of geodetic work which the Survey has at the present time. The plan also included a provision for making "all such magnetic observations as circumstances and the state of the annual appropriations may allow," and, as a result, magnetic surveys were begun soon afterwards.

The board opposed the transfer of the survey to the Navy Department, recommending that it remain in the Treasury Department "inasmuch as the object and purpose of the survey of the coast refers principally to the commercial interests of the coun-

try, and as all the laws of Congress in relation to the same, contemplate the employment of civilians and officers of the army and navy upon said work."

In accordance with this recommendation the President, in his formal approval of the plan of the board, declared that "the charge of the survey of the coast is continued in the Treasury Department and is to be under its control."

Progress Under Permanent Plan. Up to 1843 the Survey had been confined to a limited portion of the Atlantic Coast. In 1844 a recommendation made by the superintendent, and adopted, resulted in a more comprehensive system according to which work was commenced and carried on independently in many places at once, each section employing its own base and making its own geographical determinations, but all designed to form, when completed, a single continuous and unbroken chain of triangulation extending from one end of the coast to the other. At that time Texas had not been annexed, and the Pacific Coast was not in the possession of the United States.

The original recommendation, reduced to a specific form, was to divide the entire coast of the Atlantic Ocean and the Gulf of Mexico into eight distinct sections, each embracing, as nearly as could be estimated, the same length of shore-line, the work to be commenced simultaneously in as many sections as Congress would make provision for. Extensive operations in accordance with this plan were actually begun the following year. Upon the annexation of Texas and the west coast, three more sections were added, and these coasts were included in the plan of operation. When Alaska was acquired in 1867, an exploration and survey of that territory was begun.

Further Attempts to Transfer Survey to the Navy Department. In the spring of 1848 another attempt was made in Congress to transfer the Coast Survey to the Navy Department, but it was defeated in the House of Representatives. A year later a motion was made in the Senate to amend an appropriation bill by inserting the words "the said survey shall be carried on exclusively by the Navy Department, under the direction of the President." This amendment was defeated.

These attempts to re-transfer the Coast Survey to the Navy Department evoked protests from scientific societies, colleges, universities, marine insurance companies, and commercial organizations throughout the country, the protestants expressing appreciation of the work done by the survey as a civilian organization.

The efforts to transfer the Coast Survey to the Navy Department persisted nevertheless. On December 31, 1850, a resolution of the Senate called upon the Secretary of the Navy to report what advantage would be derived by a transfer of the Coast Survey to the Navy Department. It also called upon the Secretary of the Treasury to state why, in his opinion, such a transfer should not be made. The views expressed by the Secretary of the Treasury in favor of adhering to the original Jefferson-Gallatin plan were sustained by Congress.

The withdrawal of nearly all the army officers and the threatened withdrawal of the naval officers from coast survey work during the War with Mexico, and the abrupt withdrawal of all army and naval officers at the outbreak of the Civil War, appear to have strengthened the position of those in favor of a civilian bureau, and no further attempts were made for many years to transfer the Coast Survey from the Treasury Department.

Investigation by the American Association for the Advancement of Science. In 1858, in accordance with a resolution of the American Association for the Advancement of Science, a committee of twenty leading scientists made an investigation of the work of the Coast Survey. The report of this committee¹ gave a review of the survey's history, objects, methods, and results, and of its relations to other governmental departments and bureaus. The committee commended the Survey's work on scientific and practical grounds, asserted its equality with the best work ever done and its superiority in rapidity and economy to any similar work abroad, and recommended adherence to the general plan of organization.

Civil War Activities. During the Civil War the Coast Survey suspended many of the larger operations, continuing however, some of the more important branches of its ordinary work.

¹ Report on the history and progress of the American Coast Survey.

Although it remained a civilian bureau, it rendered much service to the military operations of the Union.² It made numerous reconnaissances and rapid topographical surveys for immediate military purposes about Washington, in the vicinity of Baltimore and Philadelphia, on the Virginia peninsula, at Vicksburg and Chattanooga, with Sherman's route on his march to the sea, and in connection with nearly every important operation of the army and navy. It prepared many hydrographic sheets and war maps which were supplied to blockading squadrons and commanders of expeditions. On at least two occasions the operations of the Coast Survey were largely instrumental in bringing about important victories.

Authorization of an Extensive Geodetic Survey. By an act approved March 3, 1871 (16 Stat. L., 508), the field operations of the Coast Survey were extended by the authorization of a geodetic connection between the Atlantic and Pacific coasts of the United States. The result was a great transcontinental arc of triangulation along the thirty-ninth parallel of latitude, one of the most famous arcs in the history of geodesy. This transcontinental triangulation joined the many separate parts of the Survey's work and made them into one continuous system dependent upon the same geodetic and astronomical data. The nature of the country traversed by the arc developed new ideas in reconnaissance, signal building, triangulation, and methods of computing, which have had an important bearing on all the subsequent work of the Survey.

In the execution of Hassler's plans, an arc of triangulation had previously been executed, extending from the Bay of Fundy to the Gulf of Mexico at New Orleans.

In addition to these two arcs, the Coast and Geodetic Survey has executed triangulation systems extending along the ninety-eighth meridian and along the Pacific coast from Canada to Mexico; from the ninety-eighth meridian in Texas across New Mexico, Arizona, and California, connecting with the Pacific coast triangulation; from the triangulation along the thirty-ninth parallel in Colorado northward to the Canadian boundary; and from the triangulation along the Atlantic coast to the Mississippi River at Memphis.

² Coast and Geodetic Survey, Special Publication, No. 37.

A tertiary triangulation for topographic and hydrographic purposes has been completed along the entire Atlantic and Gulf coasts and the coasts of Porto Rico and the Virgin Islands, and along practically the whole of the Pacific coast except Alaska, where, however, some progress has also been made. In the Philippines the main triangulation has been practically completed.

Incorporated in the system of triangulation of the Coast and Geodetic Survey and placed as one datum are the triangulation systems executed by the Lake Survey and by the United States Corps of Engineers.

The act of 1871 also authorized the extension of aid to states for the survey of their territory whenever provision was made by them for their own topographical and geological surveys.

Change of Designation to Coast and Geodetic Survey. With the enlargement of its functions the name of the bureau was changed, in the act of June 20, 1878 (20 Stat. L., 206, 215), to "Coast and Geodetic Survey." Its operations, however, had always been conducted in conformity with the requirements of geodesy, at least, while under civilian control. This was provided for both in the original plan of 1807 and in that of 1843. The transcontinental operations were strictly related to the survey of the coasts. They supplied incidentally to the traversed states, accurately located points upon which to base their own topographical or geological surveys for the construction of county and state maps.

Recommendations of the National Academy of Sciences. By the act of June 20, 1878 (20 Stat. L., 206, 230), the National Academy of Sciences was required by Congress to examine into and make recommendations concerning the surveys that were then being made by the various government bureaus. The act provided that

The National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the survey of the Land Office, and to report to Congress as soon thereafter as may be practicable, a plan for surveying and mapping the territories of the United States on such general system as will in their judgment, secure the best

results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, documents, and other results of said surveys.

In compliance with this requirement the National Academy of Sciences reported to Congress a plan prepared by a special committee of scientists. This report, which was adopted by the academy, grouped all surveys, geodetic, topographic, land parceling, and economic, under two distinct heads; surveys of mensuration and surveys of geology. At that time five independent government organizations in three different departments were carrying on surveys of mensuration, and the academy recommended that all this work be combined under the Coast and Geodetic Survey with the new name Coast and Interior Survey. For the investigation of the natural resources of the public domain and the classification of all the public lands, a new organization was proposed, the United States Geological Survey. In this plan, the proposed functions of these two surveys and of the Land Office were carefully defined and their interrelations were provided for.

The bill which embodied the entire plan of the academy, failed of passage in Congress, although the part relating to the organization of the Geological Survey was adopted as a rider to an appropriation act approved March 3, 1879 (20 Stat. L., 377, 394).

Final Attempts to Transfer Survey to the Navy Department.

In December, 1882, a last attempt was made to bring about a transfer of the Coast and Geodetic Survey to the Navy Department. The Secretary of the Navy in his annual report, in December, 1882, recommended the transfer of this bureau, together with several others, from the Treasury Department to the Navy Department. The Secretary of the Treasury called for the views of the chiefs of the various bureaus concerned, and when these were published,³ no further action was taken on the recommendation for the transfers.

Congressional Inquiry of the Coast and Geodetic Survey, 1884-1885. A congressional inquiry of the organization and methods of the Coast and Geodetic Survey and of three other scientific bureaus was begun in 1884, the act of July 7, 1884 (23 Stat. L., 194,

³ Treasury Document No. 395 (January 1883).

219), having provided for the appointment of a joint commission of three Senators and three members of the House of Representatives to make such an inquiry "with the view to secure greater efficiency and economy of administration of the public service in said bureaus."

This congressional inquiry was carried on for nearly two years. That portion of its report⁴ which related to the Coast and Geodetic Survey included written and oral statements from the National Academy of Sciences, scientific experts, naval officers, and hydrographers. The majority of the joint commission, in whose views both houses of Congress concurred, declared that they

do not feel justified in proposing a change in the organization and method of the Survey unless the most urgent reasons therefor can be given, especially in view of the fact that those best qualified to judge who have testified before the commission, including some eminent officers of the navy, uniformly agree that, at least until the Survey of the Coast shall be completed, the work should be continued under the present organization.

Standard Datum. In 1901 the Survey adopted the "United States standard datum." This placed the geodetic work of Survey on one datum for the correct coördination of the geographic latitudes, longitudes, distances, and azimuths. It was later adopted as the standard datum for geodetic operations in Canada and Mexico.

Spanish War Activities. During the Spanish War, practically the whole organization of the Survey was engaged in work required by the War Department and the Navy Department.

Transfer of Survey to Department of Commerce. On July 1, 1903, when the Department of Commerce and Labor was created by the act approved February 14, 1903 (32 Stat. L., 826), the Coast and Geodetic Survey was transferred from the Treasury Department to this new department. When the Department of Labor was created by the act of March 4, 1913 (37 Stat. L., 236), the Coast and Geodetic Survey remained in what was thenceforth designated as the Department of Commerce.

World War Activities. An act approved May 22, 1917 (40 Stat. L., 87), empowered the President, in time of national emergency,

⁴ 49 Cong. 1 Sess., S. Rep. 1284.

to transfer to the service and jurisdiction of the War Department and the Navy Department such vessels, equipment, stations, and personnel of the Coast and Geodetic Survey as he might deem for the best interests of the country, and provision was made for their return to the jurisdiction of the Department of Commerce after such emergency had ceased.

Under this authority five of the vessels of the Survey, with their complement of commissioned and other officers and enlisted men were transferred to the Navy Department by executive order of September 24, 1917, and a number of commissioned officers and others were transferred to the army. The commissioned officers were commissioned as officers in the army or navy in grades corresponding to the positions held by them in the Survey. At the close of hostilities these men and vessels were returned to the Survey.⁵

Changes in Personnel System. From the beginning of the Survey of the Coast, army and naval officers have participated, with the civilians, in the field work. Under the plan adopted in 1843, the work on shore was divided between civilian assistants and officers of the army, and the hydrographic work was almost entirely in charge of officers of the navy. In 1861 the officers of the army and navy were withdrawn from the Coast Survey on account of the Civil War, and since then no officers of the army have been assigned to duty on the Survey. After the Civil War the assignments of officers of the navy gradually increased in number, so that the hydrographic work was about equally divided between them and the civilian assistants of the Survey. In 1898 the officers of the navy, on account of the war with Spain, were all relieved from duty with the Survey, and in 1900 (31 Stat. L., 588, 600), Congress made provision for the establishment of the Survey on a purely civil basis, resulting in a complete reorganization.

By the act of May 18, 1920 (41 Stat. L., 603), the commissioned officers of the Survey were given a pay status equal to the other commissioned forces of the federal government, holding relative rank with officers of the navy. The act of June 4, 1920 (41 Stat.

⁵ See Coast and Geodetic Survey, Special Publication No. 82.

L., 929), changed the title of the chief executive from superintendent to Director.

International Activities. In the work of establishing the boundaries between the United States and Canada, and between Alaska and Canada, the Superintendent of the Coast and Geodetic Survey, in coöperation with a representative of the British Government, performed the task of mapping the territory contiguous to the boundaries for the boundary commission, and of subsequently demarcating the boundaries and erecting boundary monuments. These tasks were performed at various times between 1857 and the present.

When Russia ceded Alaska to the United States the Coast Survey put its expert cartographers at work to compile an official map of the newly acquired territory for the use of the Department of State. This map bears the date 1867.

Between 1891 and 1895, when the United States and Mexico were engaged in remonumenting their common boundary line, a representative of the Coast and Geodetic Survey was one of the three commissioners appointed to perform the work, and the Survey further coöperated by making determinations of geographical positions for the international commission.

In this work of demarcating boundaries the geodetic surveys of Canada, Mexico, and the United States agreed informally to compute their geographical positions on the same reference spheroid, and to use the Coast and Geodetic Survey datum, the designation of the latter having consequently been changed to "North American datum."

In 1889 the United States became a member of the International Geodetic Association, which was founded in Europe in 1861 and was made international in character in 1886. As early as 1878, however, the Coast and Geodetic Survey had sent one of its officers to a conference of the association. As a member of that association the Coast and Geodetic Survey coöperated with similar services in other countries in the establishment of a chain of small observatories around the world, with the object of obtaining a continuous series of observations on the variation of latitude.

Many other activities have been undertaken by the Coast and Geodetic Survey, jointly and under formal agreements with other

countries, including chronometric longitude determinations in 1849 and 1850, between the United States and Europe; trans-Atlantic longitude determinations by means of the cable in 1866 and in 1870; telegraphic longitude determinations between Greenwich, England, and Brest, France, in 1872; the Labrador eclipse expedition of 1860, and the solar eclipse expedition to Spain in 1870; the naval eclipse expedition of 1889 to the west coast of Africa; the transit of Venus expeditions of 1874 and 1882; gravity observations made in New Zealand, New South Wales, British India, Japan, and the Hawaiian Islands in 1882.

CHAPTER II

ACTIVITIES

Hydrography consists of determining the configuration of the bottom of the sea, lakes, and rivers, and the character of rivers, tidal and ocean currents, and their effects in producing progressive or periodic changes in the configuration of the bottom. As an activity of the Coast and Geodetic Survey, it consists of examining waters of the sea coasts as far as tide water, sounding them, and preparing nautical charts and other information for the use of navigators and for use in military defense, in the planning of harbor improvements, and in the study of oceanography. This work consists of topographic and hydrographic surveys and physical hydrographic observation studies.

Hydrographic Work. The activities of the Coast and Geodetic Survey in hydrography and topography are confined to the Atlantic, Pacific, and Gulf coasts and the coasts of the island possessions, and the rivers to the head of tide water and ship navigation of the United States. The Corps of Engineers of the War Department surveys the Great Lakes and issues charts for their navigation, and the Hydrographic Office of the Navy Department duplicates nautical charts issued by other nations and publishes charts based on surveys by the U. S. Navy of coasts not under the jurisdiction of the United States. This division of the hydrographic work of the government is required by existing law.

The chief object of the hydrographic work is to furnish navigators with such information as to the depth and configuration of the bottom, and, of the movement of currents and tides, as will enable them to lay a safe course and to verify their position at sea. The nautical charts are as essential to navigation as the compass or the engines of a vessel. These charts for all navigable tidal waters under the jurisdiction of the United States are produced only by the Coast and Geodetic Survey.

Topographic Surveys. Topography is an important feature of the work of charting the coasts, as it shows the relation of land to water for purposes of navigation and harbor and waterway improvement.

In addition to the work of triangulation and leveling for the establishment of reference marks described under the head of geodetic work, the Coast and Geodetic Survey conducts topographic operations which are mostly restricted to a narrow margin, rarely more than three or four miles wide along the coast and surrounding harbors, bays, and rivers to the head of tide water. Topographic operations of other areas in the United States come within the sphere of work of the Geological Survey of the Department of the Interior.

The topographic work of the Coast and Geodetic Survey consists of mapping the natural and artificial features of the coast, by indicating by means of symbols the "shore lines" or boundry between land and water, and "contour lines," which are lines of equal elevation above a selected plane such as the sea level; locating the rocks that show above water; indicating the character of the shores bordering on the water and their prominent and characteristic features; and locating points along the shores determined by triangulation, such as church spires, chimneys, conspicuous rocks and trees, and specially built signals, such as are suitable for observation from a boat or vessel while sounding.

Hydrographic Surveys. The hydrographic surveys consist of determining the depth of the water and outlining the channels, banks, and shoals, and locating all dangers and aids to navigation, and charting this information for the use of navigators.

When soundings are made it is necessary to have some means of determining the exact position of the vessel at the time of such measurement. The first need of the hydrographer therefor, in making his survey is a projection or outline map showing the meridians and parallels, the shore line, the character of the shore, and the land features visible from the water, prominent objects, spires, houses, artificial signals, capes, headlands, and outlying rocks and islands visible from the shore.

Soundings must be preceded by triangulation and topographic surveys, and accompanied by tidal observations; and if offshore,

by astronomical, magnetic and current observations in addition. The triangulation fixes the position of the trigonometric points on land by which the location of the soundings is determined, and the topographic survey provides the delineation of the shore, locates the rocks that show above the water, and the limits of dry shores and banks.

The points determined by triangulation are plotted on the projection, or outline map, in their proper geographic positions. These consist of prominent objects, such as church spires, chimneys, conspicuous rocks or trees, and specially built signals, all of which are of a suitable character to observe upon from a boat or vessel while sounding. Not until a sufficient number of these signals or other objects have been located and a tide gauge or tide staff has been erected at some suitable point, can any accurate and complete hydrographic survey be made.

To make these soundings, power launches and ships are mostly used. The lines of soundings are run in accordance with such a scheme as will best develop the contour of the bottom and its characteristic features. It is generally a rectangular system of lines. In a close survey the lines are spaced twenty yards apart with soundings ten yards apart in each line. When practicable the lines of soundings are run in ranges, that is, with the boat in the same straight line with two fixed objects on shore. The sounding lines are closely parallel to one another, the boat moves slowly and the soundings are taken as rapidly as the depths permit.

There are three different classes of hydrographic surveys:

1. Inshore hydrography, used in bays, estuaries, etc., and along coasts as far offshore as the surveyor can see the shore objects necessary for locating his position.

2. Offshore hydrography, when the surveying vessel starts at a known point situated at the limit of visibility of objects on shore, proceeds seaward the necessary distance, and returns shoreward until the shores can again be seen and the position located.

3. Wire-drag surveys in areas where the soundings indicate the possible existence of pinnacle rocks, boulders, or coral reefs undetected by the lead.

The necessary combinations of these three classes of work constitute a complete hydrographic survey.

Hydrographic surveys are made by the Coast and Geodetic Survey in what are designated as inland waters, inshore waters, and offshore areas.

On the Atlantic coast, inland waters include shoal bays, sounds, and tidal rivers that can be used for through traffic by boats drawing not more than ten and in most cases not more than four feet. Such waters are usually connected with the sea by shoal inlets and with other inside waters, or with each other by canals, cuts, or dredged channels.

Inshore waters include all areas of moderate depth on the outside coast, from a depth curve arbitrarily adopted outside of which no dangerous shoals are believed to exist, to the heads of navigation of all bays, sounds, and tidal rivers that have a navigable connection with the sea.

Offshore areas extend from the outer limit adopted for inshore areas to a depth curve generally fixed at one hundred fathoms on the Atlantic coast, which for most of the coast is near the edge of the continental shelf.

The Pacific coast is generally mountainous, with comparatively few harbors or inside waterways and with comparatively deep water close to the shore. The purpose of the surveys here is to meet the needs of vessels approaching from seaward and of coasting vessels which keep to a few comparatively narrow tracks to insure up-to-date charts of the various harbors and to make soundings offshore to develop fishing banks that are known to exist.

Up to the depth of about twenty fathoms the soundings are made by the lead line. This is a line marked in fathoms and feet, to which is attached a piece of lead about two inches in diameter and ten inches long. As the sounding boat moves along on a straight line the leadsman casts the lead ahead of the boat, reading the depth from the line as the lead strikes the bottom and the line becomes vertical. The point where each sounding was taken is accurately located by observers in the boat who, with sextants, measure the angles between known objects on shore.

For soundings between twenty and thirty-five fathoms, a method often used is that of dropping the lead near the bow and reading the depth as the lead comes vertical under the leadsman stationed on a platform aft. Various methods are used for carrying the lead forward and automatically releasing it.

At greater depths, including deep-sea work, the vessel is stopped while the sounding is made and a sounding machine is used. For this purpose a much heavier lead is used, and the line is replaced by a wire wound on a drum operated by steam or electricity. When taking soundings, the weight is released and the wire unwinds from the drum until the bottom is reached and the depth is recorded. Then the drum is reversed, and the wire is wound up.

As the level of the water changes with the tide during the sounding operations, a common plane of reference must be established, and the sounding must be corrected to that plane. To do this, the tides are observed by means of a staff or self registering tide gauge, while the sounding is in progress, so that the depths can be reduced to the common plane of reference, which, for the charts of the Atlantic and Gulf coasts is that of mean low water, which is, roughly speaking, the mean reading of all low waters observed on the tide staff for as long a period as practicable, but usually not less than one lunar month. Because of a difference in the type of tides upon the Pacific coasts of the United States and Alaska, Hawaii, and the Philippines, all soundings are there reduced to a plane known as "mean lower low water."

To ascertain the exact location of the vessel at the time of taking the soundings is a simple matter where shore objects are visible and the angles between known objects can be measured with the sextant. For offshore work, however, the measurement is more complicated. For fixing the position of the surveying vessel while sounding beyond the visible range of objects used in inshore surveying, the method used for determining the position of the vessel is as follows:

First, high shore signals are built. Then buoys with signals that extend as far as practicable above the water are anchored just within the circuit of visibility from the shore signals. This enables the vessel to determine its exact position as far out as buoys are visible.

Beyond that distance the location of the vessel at the time of sounding must depend upon a carefully recorded speed and compass direction, with an allowance for currents and wind pressure. This method is termed by navigators "dead reckoning." In actual practice, the uncertainties which exist in the use of this method in ordinary navigation have been reduced by stopping at intervals to

observe currents and wind pressure and starting from and returning to well-fixed positions.

The offshore surveys are not as elaborate as the surveys in shoal inshore waters where the dangers approach the surface and many more soundings are necessarily taken. The offshore surveys are mostly used by the navigator to enable him to verify his position, for by taking soundings and comparing them with those on the chart he is enabled to locate his position with fair accuracy.

As even close surveys leave areas between sounding lines which may contain boulders or pinnacles dangerous to navigation, another method than the use of the lead line had to be devised to insure safety to navigation in regions where pinnacle rocks, isolated boulders, and coral reefs rise abruptly from the general contour of the bottom.

The method in use is what is known as the wire-drag survey. The wire-drag consists of a horizontal member known as the bottom wire, which is composed of a number of sections or units of double galvanized, seven-strand, steel wire, one-eighth inch in diameter, supported at intervals by uprights, made of flexible wire cable, with suitable buoys and sinkers, and at intermediate points by hollow metal floats. At each end of the drag are large buoys. The intermediate buoys are smaller, and when at rest project about six inches out of the water. Tow lines from the power boats are attached to the larger buoys and sinkers in such a way as to permit changing the depth of the drag while in use.

This wire-drag, which may be from 3000 to 12,000 feet in length, is dragged through the water at any desired depth until some hidden obstruction is encountered. When this is definitely located, the exact extent and character of the obstacle is developed by repeated careful soundings by a separate party while the drag is released and continues the sweeping operations. The usual speed of the drag through the water is from a mile and a half to three miles per hour. Boats of eighty horsepower and fourteen-foot beam are now being employed for handling and towing the drag.

While the wire-drag will catch on any obstruction coming above the depth to which it is set, it furnishes no information of the depth of the water below the depth of the drag. This can only be learned by making soundings with the lead and line.

After the execution of the hydrographic field work the rough original sheets are closely verified by replotting the soundings and drawing the contours. After this, the finished drawings are made, which are engraved and printed. This work is done by trained experts.

Hydrographic surveys have been made along the Atlantic, Gulf, and Pacific coasts, at the approaches to the Panama Canal, and along the coasts and inland waters of Alaska, the outlying islands of Porto Rico, the Hawaiian group, and the Philippines. Some harbor surveys were made at Guam by the U. S. Navy. Much, however, remains to be done in the way of original surveys in some of these localities.

The Coast and Geodetic Survey is constantly confronted with the problem of deciding which of the surveys made to date are adequate, and which should be supplemented by additional work; and which unsurveyed regions should be sounded and what wire-drag work should be undertaken.

On coasts of fixed character, where complete hydrographic surveys are made to a depth sufficient to safeguard any future increase in the draft of vessels, the results of the bureau's surveys are good for all time. In changeable areas, however, they must be repeated, and experience has enabled the hydrographic engineer to judge how often resurveys are required. For this there are some known natural laws that can be relied upon.

Every inlet has its sand bar across its mouth, and the frequency of the necessity of resurveying the bar is determined by local conditions. Some inlets require resurveying every year, some every ten years, while others require them about once in fifty years.

On sandy shores the action of the sea waves and currents on the outlying shores is continuous, with the result that while one year one finds open waters sufficient for any steamer, the next year one may find a sandy coast. Usually severe hurricanes cause the shifting of the sandy bottoms, obstructing the accustomed steamship routes and necessitating immediate resurveys of large sections of the coast.

In all important harbors two or more different surveys have been made, not only where the surveyed areas are changeable but also where the areas are unchangeable, because of the changing conditions in navigation. In the days of sailing vessels, when the

draft of merchant vessels did not exceed twenty feet, when sailing vessels often had to beat back and forth across the harbor in order to enter it, there was no need for one deep, clearly defined channel, but it was necessary to know the location of the dangerous shoal areas over the entire harbor, and surveys were made accordingly.

With the introduction of steam vessels and the increase of draft which now requires a depth of forty feet for some of them, it became necessary to seek out in each harbor the deepest channel available in the harbor, as commerce favors the one with the deepest channel. This necessitated resurveys, not so much of the entire harbors, but closer examinations to locate and define these channels.

Therefore, during this development, the methods of making hydrographic surveys of harbors have been as follows: During the sailing ship period, the surveys consisted of a system of widely spaced sounding lines over the entire harbor, with many additional close soundings at any place on these lines where depths of about twenty feet or less had been found. In other words, the object of the surveys was to locate the shoal areas rather than the deep areas.

Then, when commerce came to be carried in steam vessels that could follow a definite course and which required a greater depth, the critical examination with the hand lead line extended not over the entire harbor but along the course of the deep channels, and these examinations show close lines of soundings in finding these channels but no close examination of the rest of the area of the harbor.

Hydrographic surveys have been sufficiently advanced to date to show where the deepest channels are in all harbors under the jurisdiction of the United States.

In the making of hydrographic surveys, whether contiguous or separated by thousands of miles, the same plan has been followed throughout the existence of the Survey; namely that the survey of the country should be controlled by a connected system of triangulation in order that the position of any selected point on a surveyed area might be readily determined with relation to any other point or points on the surface of the earth which have been previously connected with the triangulation. With this accurate control, the position of a newly surveyed area can be determined with

exactness with relation to completed surveys, and little or no confusion results.

Ocean Current Studies. Under special authorization of Congress, much time and energy have been devoted, especially in recent years, to the observation and study of ocean currents. The work consists of determining where and under what conditions currents exist, and ascertaining their strength and direction. Such studies are designed to safeguard navigation, since many disasters are due to the action of unseen and unsuspected ocean currents.

Currents have been divided into three classes: (1) Tidal currents which are the result of known forces, acting under known conditions and which can be predicted without difficulty; (2) currents, such as the Gulf Stream, where the occurrence is continuous, the flow is always in one direction, and the velocity at any point is fairly constant except when temporarily modified by weather conditions; and (3) currents which may be described as accidental in character, occurring apparently as a result of certain transitory localized causes, and which in consequence are variable.

The activities of the Survey in the study of tidal currents consist of securing data on which to base predictions of these currents at any given point, by taking continuous measurements of the velocities and the directions of the currents actually existing and noting the times of slack water as the current turns from flood to ebb or ebb to flood. As the principal tide-producing force is the combined attraction of the sun and moon, and as the relation of these two bodies to each other is constantly changing, passing through a complete cycle once every lunar month, the tides pass through similar monthly cycles. From the data obtained for any one lunar month, the currents which will occur during any other month can be predicted, subject to temporary fluctuations due to storms, freshets, etc. For these observations it is usually practicable to use small launches, and the necessary results can be obtained at small cost.

Continuous currents which flow in one direction require observations extending over a much longer period than tidal currents, in order to include the effects of varying weather conditions. These observations include the determination of the velocity of the current at different points under normal conditions and the extent to which that velocity is affected by different weather conditions.

Currents which are accidental in character offer a different problem than the preceding ; and they require a long period of observations for solution. The chief essentials necessary for furnishing navigators with information regarding these currents is a series of actual measurements of the currents extending over periods varying in length with the character of the currents.

Ocean current measurements at the surface where the depths are not too great, are made by means of suitable floating instruments attached to anchored ships, the instruments measuring the direction and velocity of the currents. For underwater measurements specially devised current meters are used.

In making current observations, small launches are used in the inland waters where shelter is afforded, where the currents are tidal, and where observations over short periods only are necessary.

In the open unprotected waters of the outside coasts where observations must be taken continuously over long periods and where it is particularly important to obtain such observations during periods of stormy weather, a staunch seaworthy vessel is required. Congress has not made sufficient appropriation for building or chartering a vessel solely for this purpose, and the Survey has to rely upon the current information obtained during the course of the various hydrographic surveys.

A plan was evolved some years ago for coöperation with the Bureau of Lighthouses in the making of current observations. This plan provides for continuous current and meteorological observations made throughout the year at the lightships which are anchored along the coasts. From the data thus obtained it is deemed possible to derive general laws on which reliable predictions can be made as to the direction and strength of currents under all conditions. Observations and reductions of currents were made at ten light vessels on the Atlantic coast and at five vessels on the Pacific coast during the fiscal year 1921.

While engaged in determining the magnitude and nature of the currents that affect navigation, the Survey has secured without additional cost, data for a comprehensive study of oceanic circulation, which have an important bearing upon many problems in meteorology, climatology, and related subjects.

Tidal Observations and Predictions. Tidal observations are made in order to determine the mean sea level from which heights

are reckoned; for reducing soundings to what they would be if made at low water; and for predicting the rise and fall of tides for the use of navigators, engineers, and others. They are important not only in hydrographic surveying, but their results are of considerable value to navigation especially since, with the advent of deep-draft vessels of modern commerce, the tides have become of considerable importance, for the state of the tides determines when certain harbors may be entered, when bars may be crossed, and when short cuts over shoal places may be attempted.

The times and heights of the tide are considerably influenced by terrestrial agencies, such as river discharge, winds, and variations in atmospheric pressure. Consequently any plane of reference, such as that of mean low-water, if determined from a short series of observations at one time, may differ considerably from the low-water plane determined at another time. It is, therefore, necessary to have a long series of observations at a number of important points which are representative of the tidal conditions of large areas. Short series of observations may then be corrected by comparison with simultaneous observations at the representative points.

Where tidal observations cover but a short period of time, a simple staff is used. This is of a greater length than the extreme fluctuations of the water surface in the locality and is graduated and secured in a vertical position. The observer notes the level of the water on this staff at definite intervals, usually quarter-hourly, half-hourly, or hourly. For long series of tidal observations, use is made of self-registering or automatic tide gauges.

Long series of tidal observations furnish the data necessary for the correction of short series observations; they are the means for securing an accurate determination of the plane of mean sea level, which is the datum used in precise leveling and in other engineering work; they furnish data used in the study of the phenomena associated with earthquakes and storms; and they supply the basic material for the study of the complex phenomena of the tides.

Along the coast, wherever tides are observed, the Coast and Geodetic Survey has established bench marks, the elevations of which, with reference to the planes of local high water, mean sea level, and low-water, are determined. These bench marks fur-

nish for local use accurate data regarding the various planes of reference made use of by engineers in the construction of wharves, docks, and other works of harbor improvement and coast protection.

For the use of the navigator, the Survey publishes annually in advance tide tables giving for every day in the year, the times and heights of high and low water for the more important parts of the world and also the times of slack current at the important ports of the United States. The tide and current predictions are made by the use of a machine known as a tide predictor. This machine, after being adjusted to make predictions for a particular port, shows accurately, by the turning of a crank which moves a system of pointers over dials, the time and height of high and low water for each successive day of the year at the port for which it is adjusted. Owing to the efficiency of this machine, which eliminates an enormous amount of laborious numerical work, the Survey is enabled to issue annually in advance the "Tide Tables, United States and Foreign Ports," which give the predicted times and heights of high and low water for every day for eighty-one of the principal ports of the world. They also give the tidal differences which enable the mariner to obtain the tides for about 3500 ports in all parts of the world.

The tidal observations and reductions during the fiscal year 1921 were made at seven principal stations on the Atlantic Coast, three on the Gulf Coast, three on the Pacific Coast, and three in Alaska. The prediction of tides and currents for the 1922 tide tables were made in three separate parts: Tide Tables, Atlantic Coast; Tide Tables, Pacific Coast; and Tide Tables, United States and Foreign Ports.

In the fiscal year 1921, 22,687 printed copies of the tide tables were distributed. In addition, many thousands of private tide tables are copied annually directly from the official tables and issued all over the country in the form of separate tide tables for different localities, and in almanacs and calendars, and in the daily newspapers.

Oceanography. In connection with the hydrographic work, the Coast and Geodetic Survey includes in its activities other oceanographic studies, such as measuring the extreme depths of the ocean, and observing the temperature, density, and chemical

properties of the sea water, and other physical phenomena of the sea that are not of a biological nature.

Preparation of Nautical Charts. The field data resulting from the hydrographic work are sent to the Washington office, or in the case of the Philippines, to the Manila office, where the data are critically examined by experts. Hydrographic and wire-drag surveys are always unfinished when sent in from the field owing to the necessity of supplying final tidal reductions and other information and applying checks which can be done only in the office. Expert hydrographic draftsmen in the office complete the plotting, inking, and verification of these sheets.

After the surveys and field data have been examined and adjusted, the information is ready to be used by the cartographers in the production of nautical charts. In the preparation of nautical charts the Mercator projection is used. Charts formerly constructed on the polyconic projection and now in print are being replaced by new Mercator charts as rapidly as conditions permit. In addition to the representation of the hydrographic and topographic features of the areas charted, much information in condensed form relative to the variation of the magnetic compass, tides, currents, meteorology, and descriptive notes concerning channels, dangers to navigation, and other related subjects are entered on the charts.

After this information is recorded on the chart drawing or compilation by a cartographer, another verifies every detail, giving especial attention to those features, the omission or misplacement of which might result in disaster to navigation. The compilation of a chart is a tedious and expensive undertaking, requiring months to complete. The next step is the preparation of the chart for reproduction, either by making an artistic, smooth drawing of the finished compilation or by engraving it on copper.

The charts are reproduced either by plate or lithographic printing, the former method being used only for engraved charts for which there is a very limited demand. In lithographic printing the photo-lithographic process is used both for those charts which have been engraved and those for which smooth drawings have been made.

The charts are issued in small editions because of the frequent revisions necessary on account of the changes in the number, posi-

tions, and characteristics of the lighthouses, beacons, and buoys maintained along the coasts, the river and harbor improvements resulting in deeper and wider channels, new breakwaters, changes in the water fronts of harbors and the growth of cities and towns along the coast, and the natural changes due to the action of waves and currents and the deposition of debris carried down by the rivers.

The nautical charts are primarily designed for the use of the navigator, both in the navy and in commercial fleets, but they also serve for coast defense activities, for harbor improvement work, and other similar purposes.

The charts are issued in various series in order to supply the different needs of the navigator. Some include long stretches of the coast, showing the shores, off-shore soundings, bottom characteristics, lighthouses, light vessels, outer buoys, etc., and are intended for the use of the navigator in fixing his position in approaching the coast or when sailing between distant coast ports. Other charts embrace much smaller areas, on larger scales, permitting greater fullness of detail, presenting graphically the channels that can be followed, with the depth of water, the positions of lights, beacons, and buoys, together with sufficient topography to enable the mariner to identify the locality as he arrives in sight of land. The largest scale charts are generally those of harbors.

Coast Pilots. While engaged in surveying the coast and harbors of the United States, the officers of the Survey collect much information of importance to mariners which cannot be shown on the charts. It therefore issues at irregular intervals volumes known as the "Coast Pilot" for the different sections of the coasts. These publications contain the following information: (1) A description of the principal lighthouses, light vessels, and fog signals; lists of life-saving stations, storm-warning display stations, and seacoast telegraph stations; and information regarding tides, tidal currents, variations of the compass, etc.; (2) nautical descriptions of the coast and harbors and general information concerning the several bodies of water and harbors, including notes relative to pilots, depth of water, draft of vessels entering the harbors, supplies, facilities for making repairs, usual or best anchorage, and other matters of practical value to the mariner; (3) sailing directions with reference to prominent objects, dan-

gers, aids to navigation, etc.; (4) appendices containing regulations relative to pilotage and harbor control and information regarding meteorologic conditions; views of important points in localities which have not yet been surveyed or which are necessary as an aid in navigation; and index maps showing the limits of the charts covering the localities treated in the volumes.

The Coast Pilot publications cover the Atlantic and Gulf coasts of the United States; the coast of Porto Rico and Virgin Islands; the Pacific coast of California, Oregon, and Washington; the coast of Alaska; and the Hawaiian and Philippine Islands.

The preparation of these volumes involves both office and field activities. The office work consists of the collection of the latest data from the reports and surveys of the hydrographic and topographic parties, from the reports and surveys of the United States engineers engaged in the improvement of harbors and waterways, and from correspondence with local authorities and engineers. This information, arranged in convenient form in manuscript, is then verified and amplified by the compilers in the field, who visit every part of the coast which is treated in the volumes. Corrections are made on the spot, if necessary, and such additional artificial aids and natural landmarks as are of use to the mariner are noted and hydrographic examinations of reputed dangers and changes are made; pilots, shipmasters, and local authorities are interviewed and the latest information is incorporated, together with such notes of data as can only be obtained by observation and experience in the locality.

Upon its return from the field the manuscript, corrected to date, is prepared for the printer. The volumes are revised and passed to new editions whenever sufficient changes have occurred to make the old editions unsatisfactory. The Coast Pilots are distributed at the cost of printing and binding. During the intervals between editions, corrections are issued in the weekly "Notices to Mariners," on insertion sheets, and in the form of supplements.

Geodetic Work. A geodetic survey is one in which the shape and size of the earth are taken into consideration. With few exceptions, all government surveying operations, especially the work of the Coast and Geodetic Survey, the topographic mapping of the Geological Survey and much of the survey work of the General

Land Office are geodetic in the sense that the curvature of the earth is taken into consideration. It is claimed¹ that the geodetic work of Coast and Geodetic Survey, by the magnitude of the operations, by the instruments employed, and by the economy and speed and cost is without equal in the geodetic world.

In order to make surveys over large areas and to have the results harmonious, it is necessary to locate very accurately some points that can be used to control the position of the surveys. To determine the geographic position of these points and their distance and direction from one another, the processes of triangulation or traverse are employed. The elevation of control points, or bench marks, is determined by precise leveling. Astronomic observations are a necessary part of this geodetic work.

When an area to be surveyed is small or unimportant the distances may be measured directly upon the ground, with chain or tape, and the directions obtained by the use of a compass or surveyor's transit. But when a survey is to cover an extensive territory, or when great precision is desired, the method of triangulation or of traverse is resorted to.

Triangulation. Triangulation consists of determining distances between prominent points by proceeding from a base line the position of whose extremities has been ascertained with extreme care, measuring the angles of the triangle formed by the base line and a given object, and ascertaining the distance and position of the latter by trigonometrical calculation. This calculation rests upon the proposition that if one side and the angles of a triangle are known, the remaining sides can be computed. To carry on triangulation the objects whose positions are to be determined must be visible from at least two of the occupied stations.

In order to utilize triangulation to the best advantage, some system of coördinates must be adopted in order that a point of the triangulation may be given a position that will harmonize with the position of the other triangulation points or stations. The origin of coördinates adopted by the United States and by nearly all other countries is the intersection of the meridian which passes through the observatory at Greenwich, England, and the earth's

¹ Centennial Celebration of the U. S. Coast and Geodetic Survey, 1916, p. 87.

equator. This intersection of the meridian and the equator has a zero longitude and zero latitude, and all points in the United States which are referred to these two lines, will have north latitude and west longitude.

The triangulations are classified as "precise," "primary," and "secondary," according to their accuracy.²

Precise triangulation is used in extending the fundamental control over the country and in accurate city surveys. It is used as the framework for all other surveys. In precise triangulation work the economical length of the line between two points is considered to be from fifteen to forty miles.

The first step in the work of triangulation is the reconnaissance, upon which the success of the work largely depends. It consists of the collection of all information that will be valuable in future operations, including the selection of stations, the location of base lines and sources of supplies for the parties, and the erection of towers when required.

In a triangulation it is necessary to determine by direct measurement the length of one of the lines of the scheme, or base line, from which to start in measuring the angles and computing the other lines of the triangulation. It is usual, in an extensive scheme, to measure additional bases at intervals which depend upon the strength of the figures in the scheme. This prevents an undue accumulation of error in the length of the lines. These bases are measured with great accuracy by means of tapes made of an alloy of nickel and steel called invar. The merit of this alloy for this purpose is its low coefficient of expansion, which is only four-ten-millionths per degree centigrade. The measurement of a base is a simple operation but requires extreme care and accuracy. It is usually done by the triangulation party.

When the reconnaissance of a region has been completed, and the base line has been established and measured, the three angles of each triangle are carefully measured by the use of theodolites. After measuring the angles, the triangle sides are computed. The latitude and longitude are ascertained by geodetic formulas. All distances determined by triangulation are referred to sea level.

² Coast and Geodetic Survey, Circular No. 30.

In primary and secondary triangulation the same general principles apply as in *précise* triangulation, but the angles are usually measured with smaller theodolites and a smaller number of measurements is made. In a secondary system the object is primarily to furnish points for topographic and hydrographic surveys. Primary triangulation is usually used in connecting *précise* triangulation with the secondary work.

By *précise* triangulation, the distance between two points may be obtained with an error of not more than one-hundred thousandths of the distance, that is, if the distance is one hundred miles, the error will probably be less than five feet. The accuracy of each of the three classes of triangulation is represented by an average closing error of a triangle of about one second of arc in *précise* triangulation, not more than three seconds in primary, and not more than five seconds of arc in secondary triangulation.

Whenever the triangulation is to serve a further purpose, the stations are marked in a permanent manner by establishing at every station a standard metal triangulation mark which is set in rock or concrete. There is also placed an underground mark which is separated from the surface mark. In addition there is set at least one reference mark, which is referred to the station by an angle and distance. The reference mark serves in place of the station mark if the latter is destroyed, and aids in the recovery of the station mark. Each station and reference mark disk bears a warning of fine or imprisonment for disturbing it.

In the execution of every triangulation scheme accurate descriptions of all the stations are made so that anyone who is unfamiliar with the locality may be enabled to find the exact point determined and to identify positively the monuments marking the stations.

Arcs of triangulation have been executed extending along the coast from the Bay of Fundy to the Gulf of Mexico at New Orleans; along the thirty-ninth parallel of latitude from the Atlantic to the Pacific; along the ninety-eighth meridian and along the Pacific Coast from Canada to Mexico; from the ninety-eighth meridian in Texas across New Mexico, Arizona, and California, connecting with the Pacific Coast triangulation; from the thirty-ninth parallel in Colorado to the Canadian boundary and from the

triangulation along the Atlantic Coast to the Mississippi River at Memphis, beside many shorter arcs.

The extension of a precise and primary triangulation over the whole country enables the engineers and surveyors to coördinate all public and private surveys wherever made.

The United States, Canada, and Mexico have decided to extend their precise triangulation in such a way as to have it continuous over the whole continent, thus making it possible to obtain accurate distances and directions between points of one country and those of another.

It is expected that eventually the fifty miles which separate Alaska from Siberia will be spanned and a junction effected with the great systems of Asia, Europe and Africa, and that the system will be extended from Mexico through Central and South America.

Traverse. In regions where the area is so flat or so heavily wooded that it would be excessively expensive to carry on triangulation, owing to the necessity of having high signals to elevate the surveying instruments above intervening obstructions, the process of traverse is resorted to. This is a surveying operation designed to furnish the latitudes and longitudes of a number of points which form the control or base stations for detailed surveying operations. The traverse lines nearly always follow railroads and, therefore, very little signal building and clearing of lines are necessary.

Precise traverse as carried on by the Coast and Geodetic Survey consists of a series of base lines placed end to end, the measurement of each of which is made with almost the same accuracy as is used on precise base lines. The angle formed by each two contiguous lines of traverse is measured in the same way as in precise triangulation, but only about half as many measurements of the angle are made. The probable error of the measurement of an angle is about double that of precise triangulation. The lines between traverse stations are shorter than in precise triangulation, these stations being usually not more than five miles apart. Whenever a traverse runs through a town of considerable size, at least two traverse stations are established close to it in order that the results may be used by the local engineers and surveyors in their work.

The traverse line usually starts from some station of the triangulation net of the country whose latitude and longitude, and the azimuth of one of the triangulation lines radiating from it, have been determined. After the distances and angles of the traverse have been measured, the geographic positions of each of the stations of the traverse can be computed and the azimuths of the lines of the traverse can also be obtained by combining the angles measured along the traverse with the azimuth of the line of the triangulation from which the traverse is started. At frequent intervals along the traverse the azimuth of a line is determined astronomically.

At the Washington office of the Coast and Geodetic Survey an adjustment of the traverse line is made to fit into the general network of the triangulation and traverse lines of the country, so as to avoid any inconsistencies in the work.

As in triangulation, each traverse station is marked by a metal disk properly inscribed, set into solid rock, or into especially constructed blocks of concrete.

The traverse has this advantage over triangulation that its stations are much closer together and are in places that are more accessible. Such stations, therefore, can be used by the surveyors and engineers to greater advantage. Besides, the traverse lines are generally run along railroad tracks where transportation of parties, instruments, and equipment is easier than in triangulation.

After the completion of the work in the field and the office, the results of the precise traverse, consisting of the geographic positions of the stations, the distances and azimuths of the lines, and the descriptions of the stations, are published in pamphlet form for the use of engineers and map makers.

The Coast and Geodetic Survey has not carried on any secondary traverse.

While traverse was formerly very little used in control surveys by the Coast and Geodetic Survey, since 1917 an elaborate system of precise traverse lines has been established in Georgia, Virginia, North and South Carolina, Florida, Louisiana, Indiana, Illinois, and Wisconsin for the purpose of furnishing control for military and other maps of the parts of the country through which the lines run.

Leveling. Leveling is a process by which the heights of objects above mean sea level are determined. In order to reduce the distances between triangulation and traverse stations to a common standard of length, that is, to their length of mean sea level, to establish bench marks on which to base surveying and engineering operations, and for the solution of scientific problems concerning gravity, the tides, and other similar work, it is necessary to determine with great accuracy the elevation of certain points on the earth's surface. This is done by the process of precise leveling, for which specially designed instruments are used. It calls for the highest degree of accurate observation and measurement, special methods of reduction and scientific study of errors being involved.

The two principal methods now in use in the Coast and Geodetic Survey for the determination of elevations are by precise spirit leveling and by the measurement of vertical angles. The first is the most accurate method known and differs from ordinary leveling only in the sensitiveness of the instruments used, the care with which the observations are made, and the refinement of the computations; the second is of a much lower degree of accuracy, but suffices for many purposes.

Precise leveling by the Coast and Geodetic Survey is done by means of a telescope carrying a delicate spirit level mounted on a portable tripod in such a manner that it may be quickly and readily placed in a horizontal position. Graduated rods are held at two points, the instrument being placed midway between them. The telescope is sighted first on one rod and then on the other. The difference of the readings of the rods is the difference of height between the two points. The length of the sight usually does not exceed 150 meters. By repeating the operations at successive stations the difference of elevation of widely separated points is determined.

Practically all the precise leveling of the Coast and Geodetic Survey is done along the railroads, as it is more economical and the work is more accessible. A line of precise levels is always run twice, in opposite directions, and in case of disagreement of the results beyond prescribed limits between adjacent bench marks, one or more additional runnings are made. By means of precise

leveling permanent "bench marks" are established at short intervals for the use of surveyors and engineers.

Severe tests of the accuracy of leveling are obtained from the closures of large circuits fifty, one hundred, or one thousand miles in circumference, elevations being carried from one point continuously in one direction around the circuit. If there are no errors in the leveling, the computed elevation for the starting point on closing the circuit should agree with that assumed for it at the start. In the network of precise leveling which now covers the United States there are over one hundred such circuits, varying in circumference from one hundred to 4700 miles.

Since the adoption of the present instruments and methods the Coast and Geodetic Survey has made an average rate of progress of seventy-five miles per month of this leveling, each mile being leveled twice, once in a forward and once in a backward direction.

It is planned to extend the network of precise leveling over the United States until there will be but few points in the country which will not be within fifty miles of a precise leveling bench mark.

Leveling by vertical angles, or trigonometric leveling, which consists of measuring at any station the angle of elevation or depression of a distant station, is carried on in connection with triangulation. The sight in this case may be of very great length, in mountainous regions sometimes exceeding one hundred miles. The distance to the station sighted being known, the difference of elevation between the observer's station and the distant point is computed by trigonometry.

In making these computations it is necessary to apply large corrections, on account of the refraction of the ray of light coming from the distant point to the observer, but as the physical condition of the atmosphere which determines the degree of this refraction cannot be known over long lines of sight, the accuracy of the trigonometric leveling falls considerably below that of precise spirit leveling. In order to prevent the accumulation of errors and to improve the elevations determined by trigonometric leveling, these measures are connected up at various points with precise level bench marks, and the trigonometric levels are adjusted to fit the precise leveling between those points. When this has been done, the resulting heights are of sufficient accuracy to serve

as control points in contouring for all except very detailed topography. Tests of the accuracy of the trigonometric leveling indicate that it is an even chance that the difference between the two points determined by this method is correct within one or two inches to the mile when vertical angles have been observed in both directions over the line.

Gravity Measurements. The study of the force of gravity as a part of the geodetic problem has received attention for many years, and the Survey has developed methods and instruments with which the work can be done with a high standard of accuracy. By means of observations of the intensity of gravity, the earth's compression, that is, its shape, can be deduced by mathematical processes with a high degree of accuracy. A knowledge of the intensity of gravity is also essential in meteorology and for the determination of many physical constants, such as, for instance, the mechanical equivalent of heat. An extensive research has been made by means of gravity determinations, to ascertain the variations from the normal densities of the materials in the outer portion of the earth.

Determining the Figure of the Earth. An important problem occupying the attention of the Survey, from the scientific point of view is that of determining the shape and size of the earth. By using the great system of triangulation in the United States to furnish the area factor and the many astronomical measures connected with the system to furnish the curvature factors, a value for the ellipticity of the earth has been computed, which is regarded as being of a high degree of accuracy. In making these observations and computations topographic irregularities within four thousand kilometers of each astronomic station were considered, and account was taken of possible distribution of density beneath the surface of the earth. By a study of the station errors, or deflections of the vertical, which were revealed when the astronomical and geodetic determinations were compared, evidence was brought forth which established the fact that the condition of isostasy, or equilibrium exists in the earth, a fact which is of interest and value to geodesy and geology.

Magnetic Observations. The purpose of magnetic observations is to determine the direction and intensity of the earth's magnetic

field and variations in direction and intensity. From a practical viewpoint the most important observations are the direction in which the compass needle points, and changes in its direction, and the intensity of the magnetic force which directs it, and the variations of this force. This knowledge is necessary for successful work by the land surveyor using magnetic methods and for the mariner.

The magnetic needle of the compass does not always or in all places point to the geographical North Pole, but deviates more or less from place to place, and at different times in the same locality. Magnetic observations are, therefore, made at selected stations to determine what the deviation is at these stations from period to period.

While the cause of the changes in this deviation is unknown, the rate of change has been fairly, definitely determined. The information regarding these changes is essential to the land surveyor. If a survey was made forty years ago running due north from a certain mark and the variation of the compass has changed 2 degrees to the west since that time, if a line is run due north by the compass to-day allowance must be made for this deviation.

The making of magnetic observations was recognized as one of the functions of the Survey at the time of its reorganization in 1843. Up to 1877 the magnetic work was confined almost entirely to the coast states and was mostly executed in conjunction with other branches of the survey work. While some observations were made in interior states in subsequent years, the progress was very slow until 1899, when a plan was adopted and has since been carried into execution for a general magnetic survey.

This plan of 1899 provided for a first general survey with stations thirty to forty miles apart, to be followed by a more detailed investigation of regions where the general survey indicated irregular distribution of the earth's magnetism. It also included the reoccupation at intervals of about five years of a sufficient number of "repeat" stations to determine the change of the magnetic elements with lapse of time, and the operation of magnetic observatories for determining in more detail the changes in the direction and intensity of the earth's magnetic field.

In the execution of the plan, the distribution of stations has been largely upon the county subdivision of the states, the idea being

to have at least one magnetic station in each county to enable the county surveyors to test their compasses. With this end in view the stations have been marked in a permanent manner, and the true bearings of prominent objects have been determined. In many cases meridian lines have been established for greater convenience of the local surveyors. Up to the close of the fiscal year 1921, observations had been made at slightly over seven thousand land stations in the United States and outlying territories, and there remained about 175 county seats still to be occupied. The density of distribution of the stations corresponds in a general way to the density of population. For the whole of the United States the average distance between stations is twenty-five to thirty miles. About seventy-five "repeat" stations a year have been occupied. Reestablishing stations that have been destroyed and occupying stations in newly incorporated counties constitute work of a continuous nature.

There are many localities in the United States which are magnetically disturbed and require additional observations at auxiliary stations in order to be represented, with a fair degree of accuracy, on the isogonic charts. Special observations to determine the extent of locally disturbed areas have been made at about 156 places in the United States and outlying territories.

Most of the leading nations of the world are coöperating in a study of the earth's magnetism in an effort to determine its origin, the causes of its many fluctuations, and the laws which govern them. In order that accurate data may be available for these investigations, many magnetic observatories throughout the world are kept in continuous operation, recording every change in the direction and intensity of the earth's magnetic field. As the changes are found to be different in different parts of the earth, it is important to have observatories as widely distributed as possible. With this object in view, five observatories are in continuous operation in the United States, at Cheltenham, Maryland; Tucson, Arizona; Sitka, Alaska; Vieques, Porto Rico; and near Honolulu. Instruments recording photographically are kept in continuous operation at these base stations, which automatically record the ever present fluctuations of the earth's magnetism.

The results of the operations in connection with the study of terrestrial magnetism are shown on its charts and are otherwise

communicated to the public in full detail in its numerous publications on the subject.

Astronomic Work. The astronomic work carried on by the Survey is a definite part of its geodetic function. It consists of the determination of time, latitude, longitude, and azimuth. The purpose of this work is to give the location of cities, islands, and other widely separated places in connection with the surveying and mapping of the coasts and interior of the country, to locate the stations at which magnetic observations are taken; and to supply certain data needed in the adjustment of the triangulation net of the country. Astronomic work has been carried on for many years in the United States and its possessions.

Time. Time is determined by observations of the sun or stars with an instrument which measures their altitude or their meridian passage. For approximate determinations a sextant is used, and for refined work an astronomic transit. A determination of time with an astronomic transit usually consists of observations on five or six stars which are especially selected to form a group. The times of transit of the stars across the field of the telescope are noted by the use of a self-registering micrometer. In this micrometer is a movable thread which can be made to follow the star as it crosses the field. By means of a series of automatic electric contacts in the micrometer eyepiece, a record of the star's passage across the meridian is made automatically on a chronograph.

Latitude. The determination of latitude consists of determining the angular distance of an object or place north or south of the equator. Latitude of an inferior grade is determined with a sextant by observations on the sun or stars, but determinations of the first order are usually made by observations on the stars with a zenith telescope, or with an astronomical transit so equipped that the Horrebow-Talcott method of observing latitude can be used.

Longitude. The determination of the longitude of a place consists of measuring the angular distance between the adopted initial meridian plane and the plane of the meridian through the place whose longitude is sought, or it may consist of determining the angular distance between the meridian through some place already

referred to the initial meridian and the meridian through the new station. The initial meridian that is in almost universal use is the one which passes through the observatory at Greenwich, England. As the surface of the earth in revolving on its axis moves 15° of longitude in an hour, the determining of longitude consists simply in observing the difference in the local time at the two places, one where the longitude is known and the other where it is unknown. The most exact method of determining this difference is by means of the electric telegraph. Five transatlantic determinations have been made which serve to connect the longitude of the United States and Greenwich and Paris, and more than two hundred stations are included in a great telegraphic net which covers the United States.

These determinations are now principally made for the purpose of furnishing data by which the triangulation network of the country may be adjusted to the proper geographical position.

Azimuth. Observations for azimuth are made in order to ascertain the true north or direction of the meridian at various points covered by a survey or map. In the work of the Survey the direction of the true meridian must be known in connection with the triangulation and magnetic observations. Astronomic azimuths are used to control the geodetic azimuths carried through triangulation. In magnetic work the direction of the true meridian must be known in order to determine the angle between that direction and the direction indicated by the magnetic needle.

The direction of the true meridian is obtained by observations on the sun or Polaris. Data necessary, in order to compute the azimuth from the observations, are the approximate latitude of the place and the local time at which the observations are made, and in the case of the sun, the approximate longitude of the place of observation.

For exploration, reconnaissance, or magnetic observations, theodolites with horizontal circles from three to six inches in diameter are used to observe the sun or north star. For tracing meridian lines or for secondary triangulation, theodolites with horizontal circles from six to ten inches in diameter are used in connection with a circumpolar star. For the precise triangulation, twelve-inch circles, which are read to single seconds by micrometer microscopes, are needed to produce an accuracy commensurate with

the requirements of the work, and only circumpolar stars are observed to determine high-grade azimuths. Accurate time is required for this class of work.

Seismological Observations. In order to determine whether there is any relation between earthquakes and magnetic disturbances, seismographs are in operation at the five magnetic stations.

Coöperation with Other Services. The activities of the Coast and Geodetic Survey are of such a nature that they bring that service into more or less close coöperative relations with other government bureaus, especially the Bureau of Fisheries, the Bureau of Lighthouses, the Geological Survey, the Corps of Engineers, and the Hydrographic Office of the Navy Department.

The Bureau of Fisheries depends upon the Coast and Geodetic Survey for its basic triangulation and field projections whenever biological surveys are undertaken in regions in which the latter has operated. On the other hand, whenever hydrographic and topographic work is undertaken by the Bureau of Fisheries it is made available to the survey.

The Bureau of Lighthouses and the Coast and Geodetic Survey coöperate in many ways. They jointly issue a monthly "Notice to Mariners." The Survey makes special surveys when needed in connection with the selection of locations for lighthouses and determines the positions of landmarks necessary for locating buoys. The Lighthouse Service marks new dangers located in the course of surveys and changes the position of buoys and other aids to navigation shown to be necessary by revised hydrography. Some of the lightships are utilized for taking observations of ocean currents. The Bureau of Lighthouses aids the Survey with any information obtained by its vessels, or otherwise, that is of use in correcting charts. The Coast and Geodetic Survey indicates on its charts the position of lighthouses, buoys, and other aids to navigation maintained by the Bureau of Lighthouses, and, as many of these change from time to time, the work of locating the aids correctly on the charts requires close coöperation between the two bureaus.

The Coast and Geodetic Survey and the Geological Survey have much in common. While both engage in topographic work, the

activities of the former stop at the coast. The Coast and Geodetic Survey furnishes geographic positions, with distances and azimuths ascertained by triangulation and precise leveling, astronomical observation, etc., to the Geological Survey, this being basic information needed in the latter's topographic work. Each of the two surveys furnishes the other with photographic copies of field sheets of current work which are of special value in connection with the preparation of maps. On occasions, field parties of the Geological Survey have been furnished transportation on the steamers of the Coast and Geodetic Survey, and parties of both services have worked together in the field.

The Corps of Engineers has charge of the hydrographic work on the Great Lakes, which thus supplements the coast work of the Survey. The officers of the Engineer Corps have recourse to the maps of the Coast and Geodetic Survey whenever a tidal harbor is to be improved. By comparing these maps issued at different periods and studying the changes that have occurred, the probable causes of existing shoals and other dangers may be discovered and this knowledge lead to permanent improvement. The engineer officers study the tide tables in connection with their own observations of tidal ranges and periodicity, and the two services interchange such observations. When detailed surveys and investigations are to be made by the Engineer Corps to determine the nature and cost of harbor improvement work, recourse is had to the records of permanent triangulation stations established by the Survey. General information gathered by the Coast and Geodetic Survey along the coast is used, and when necessary, extended by the local surveys of the Corps of Engineers, the work of the latter often supplementing that of the former. Whenever in the course of an improvement, a new map is made by the Corps of Engineers, a copy is supplied to the Coast and Geodetic Survey and is used by the latter to revise earlier editions of its own charts. In coast defense work by the Corps of Engineers the Survey's map and the detailed description of the coasts and harbors in the Coast Pilots are invaluable aids.

By virtue of an act of June 28, 1879 (21 Stat. L., 37), one of the seven members of the Mississippi River Commission must be selected by the President from the personnel of the Coast and Geodetic Survey. The present member so selected is the Assistant

Director of the Survey. The Survey is required to detail officers and men and to place vessels, machinery, and instruments at the disposal of the commission when necessary.

The hydrographic work of the Coast and Geodetic Survey and of the Hydrographic Office of the Navy Department is similar in nature, the former being confined to the coasts of the United States and its possessions and the latter to surveys in foreign waters. The two services thus supplement each other in their work.

CHAPTER III

ORGANIZATION

The organization of the Coast and Geodetic Survey consists of the Washington office and a field force, all under the supervision of a director. The office organization consists of the offices of the Director, Assistant Director, Chief Clerk, and six divisions, some with subordinate sections. The divisions are designated : Geodesy, Hydrography and Topography, Charts, Tides and Currents, Terrestrial Magnetism, and Accounts. The Director and other engineer officers of the Survey are commissioned by the President, and have the relative rank, pay, and allowances of officers of the navy.

Office of the Director. The Director is the administrative head of the Survey. He is responsible for the correctness, efficiency, and fidelity of the work of the service, and for the proper and economical expenditure of the appropriations made therefor.

The personnel of the Director's office consists of the Director, a clerk, and a messenger.

Office of the Assistant Director. The Assistant Director performs such duties as may be prescribed by the Director, and in the absence of the latter, he performs the duties of the Director. He has under his direct charge the Section of Instruments.

Section of Instruments. The functions of this section are to keep in repair the surveying instruments and to design, make drawings for, and construct new instruments and parts thereof which are required in the operations of the service. The section is charged with the care, issue, and accounting for all instruments and general property of the service ; also their packing, unpacking, shipping, and receipt.

The personnel of the Assistant Director's office consists of the Assistant Director, a Chief of Section, three clerks, eleven instrument makers, three pattern makers, and two laborers.

Office of the Chief Clerk. The Chief Clerk has charge of the upkeep and maintenance of the buildings occupied by the Survey in the District of Columbia, and the purchase and distribution of instruments, equipment, and miscellaneous supplies for the Washington office. He has charge of the library of technical books and of the original field records in the archives. He receives and accounts for all monies realized from the sale of publications, condemned property, and for work done for outside parties. He also has charge of the time records of the entire personnel of the service, and all freight and express shipments made to and from the office at Washington.

The personnel of the Chief Clerk's office consists of the Chief Clerk, three section chiefs, nine clerks, two telephone operators, ten skilled workers, fifteen laborers, two messengers, and four watchmen.

In the performance of its duties, the office is divided into five sections: Personnel, Supplies and Shipments, Library and Archives, Mail and Files, and Engineer and Electrotypes Section.

Personnel Section. This section has charge of the details of preparing correspondence and records arising from the appointment and separation of the personnel, and of leave of absence records.

Section of Supplies and Shipments. This section is charged with the purchase of supplies and equipment for the office work, and certain supplies and equipment for field purposes. A store of stationery is maintained for the use of office and field forces, as well as necessary blank books for use in making field observations. This section also has charge of incoming and outgoing freight and express shipments.

Section of Library and Archives. This section has charge of the original records of field observations, of office computations and adjustments thereof, and the library of technical books and periodicals maintained by the Survey. In this section is prepared most of the correspondence in response to requests for publications.

In addition to the information contained in the printed publications, the results of the work of the Coast and Geodetic Survey are found in a large accumulation of original data that have not been duplicated and that are available for consultation in its archives.

The earliest records on file date back to 1816; while topographic and hydrographic surveys bear the date 1834, magnetic observations were made in 1833 and tidal work began in 1832. For over a century information has been obtained and recorded bearing upon the physical condition of that portion of the earth constituting the United States and adjacent waters. This area has been extended from time to time, and the original data now cover also Porto Rico, Hawaii, the Canal Zone, and large portions of Alaska, the Philippine Islands, and Virgin Islands of the United States. The records of observations and surveys are systematically arranged and carefully preserved, and they constitute in many cases, the only authentic record from which natural or artificial changes can be deduced.

Much of the information, in its original form is available for special use and the Survey furnishes copies of it either free or at a nominal cost.

There are also on file, original records of surveys that have been made of some state and national boundaries; many thousand specimens of the sea bottom that have been collected as the result of deep-sea soundings; and a very complete collection of charts and maps, reports and publications, including those of foreign countries, on surveying, hydrography, tides and currents, navigation, terrestrial magnetism, geodesy, and kindred subjects.

Section of Mail and Files. The Mail and Files Section has charge of the opening and distribution of incoming mail and the file of certain correspondence and field reports.

Engineer and Electrotpe Section. This section is charged with the repairs of the building and equipment, and as a part of this section, a shop is maintained where electrotypes are made of copper printing plates.

Division of Geodesy. The function of this division is to execute, through field parties, the geodetic work of the Survey, and to prepare for use the results of such field work. Such preparation includes the computation and compilation of field data and their preparation in suitable form for publication.

The field work of the division consists of geodetic surveys in extension of the network of precise leveling throughout the United States and Alaska for the control of levels run by other

government bureaus and by state and city officers, private individuals, and corporations; the determination of geographic positions by triangulation or traverse for the control of national, state, and county boundaries, and other engineering work in all parts of the United States and Alaska; and the determination of field astronomic positions and the establishment of stations at which the intensity of gravity is determined. Along the coasts the triangulation done by the Survey comes indirectly under this division, since the results are computed and filed here. Such triangulation is of a detailed nature, intended for the control of topographic and hydrographic surveys made by the field parties in the construction of nautical charts.

The office work consists of the computation and adjustment of triangulation, including astronomic observations; the computation and adjustment of precise leveling; the computation of field observations made for the determination of the intensity of gravity and researches in isostasy; geophysics in the form of research of the subject of the strength of the earth's crust or isostatic shell, and certain physical properties of the material of the shell; preparing such data for publication; and furnishing information within its sphere to officers of the Coast and Geodetic Survey and other government organizations and to the public in response to requests.

Most of the work of the division is of a purely practical character and is of immediate commercial or industrial value.

The office personnel of this division consists of a chief and an assistant chief of division, seventeen computers, two clerks and a draftsman. On March 1, 1922, there were engaged in geodetic work in the field, twelve hydrographic and geodetic engineers, one junior engineer, two signal men, one extra observer, and a force of hands engaged in rodding, chaining, recording, heliotroping, etc., on field parties.

Division of Hydrography and Topography. This division has charge of all the hydrographic and topographic surveys executed along the coasts of the United States, Alaska, and the insular possessions, principally Porto Rico, the Hawaiian Islands, the Philippines, and the approaches to the Panama Canal. Its functions include the determination of where surveys or resurveys are

required, how they shall be conducted, the preparation of instructions for surveying parties, the organization of the parties, the examination of the records, and inspection of the field work. It has charge of the construction, maintenance, and repair of the vessels and other field equipment (except instruments), the records of the seamen employed on this work; and the preparation of the Coast Pilot and sailing directions in the field and office.

It has supervision over the five field stations located at Boston, New York, New Orleans, Seattle, and San Francisco, and over the branch office at Manila. These field services are established to maintain close relations between the Survey and those who have occasion to use its charts, publications, and data, and to keep it informed of the needs for further work in these general localities.

For administrative purposes the division is subdivided into three subordinate sections, designated as the Section of Field Work, the Section of Vessels and Equipment, and the Section of Coast Pilot.

Section of Field Work. The Field Work Section has charge of the preparation of outlines of survey projects and the formulation of plans for their execution. It advises as to the conduct of all field operations. The chief of this section has charge of the division in the absence of its chief.

Section of Vessels and Equipment. This section has charge of the purchase and maintenance of vessels and all equipment of hydrographic and topographic parties. It prepares plans and specifications, and supervises the repairs to the fleet and the construction of new vessels. Its duties include frequent inspection of the vessels, their equipment and personnel.

Section of Coast Pilot. The Coast Pilot Section collects information for and compiles the Coast Pilots and Inside Route Pilots for the coasts of the United States, Alaska, and the insular possessions. The field work of the section enables its members to advise the chief of the division of the condition of the surveys and discrepancies in the published charts.

Field Stations. The Manila office and the five field stations are under the immediate administration of the chief of the division.

The personnel of the division at the Washington office consists of a chief of division, an assistant chief who is also a section chief, two section chiefs, three clerks, and a draftsman. The Manila

office has a director in charge, one chief clerk, one chief of computing division, one chief of drafting division, one chief of chart division, one chief and one assistant chief of photo-lithographic division, one bookkeeper, one property clerk, two clerks, two computers, four readers, twenty-four draftsmen, two chart correctors, one photographer and two laborers. Three of the field stations have each an inspector and a clerk; one other has an inspector and a tide observer and skilled laborer, who acts as a clerk; the fifth field station has an inspector in charge, one clerk and one tide observer and skilled laborer.

On March 1, 1922, there were engaged in hydrographic and topographic work in the field, eighty-six hydrographic and geodetic engineers, twenty-nine aids, eleven deck officers, twelve chief marine engineers, five mates, three surgeons, and 543 petty officers, artisans, rated men, seamen, and hands.

Division of Charts. The Division of Charts has charge of reviewing, verifying and completing the field sheets; preparing new charts from the results of field work or from other sources; keeping existing charts up to date by the addition of new data; preparing the notes for notices to mariners; engraving the copper plates and making the photo-lithographic plates from which charts are printed; photographic work; and the printing, sale and distribution of the charts. It maintains complete indexes and diagrams of all surveys and of reports of dangers to navigation, harbor improvements, and changes in aids to navigation.

The division has five sections: Field Records, Drafting, Printing and Sales, Engraving, and Photography, each in the charge of a section chief.

Section of Field Records. This section reviews, verifies, and completes the final sheets from the records of the field observations, made under the direction of the Division of Hydrography and Topography; reports on the sufficiency of the surveys; indicates, for correction, departures from approved methods; and notes for the use of the service, practices worthy of general adoption. It is the custodian of all the original hydrographic and topographic field sheets of the Survey. The chief of this section is also assistant chief of the division.

Section of Drafting. The Drafting Section compiles the results of surveys and all other information for new charts, and for new

editions, and new prints of charts. It prepares the working drawings of charts for the engravers, and smooth drawings for reproduction by photo-lithography; constructs projections on copper plates for the engravers; verifies proofs of all engraved work and of the lithographic charts each time one goes to press. It examines, diagrams, and indexes all charting data received; indicates the corrections to be made by hand on the printed charts; and does miscellaneous drafting work for the Survey and for other bureaus of the government.

Section of Printing and Sales. This section attends to the printing of charts from the copper or aluminum plates on plate and lithographic printing presses; correcting the charts by hand for dangers and changes in aids to navigation; and has charge of the sale and distribution of these charts and other nautical publications. It is equipped with a shop where electrotypes are made of the engraved copper plates.

Section of Engraving. The Engraving Section engraves the charts on copper plates from the compilation drawings furnished by the Drafting Section, making new plates for new charts and correcting existing plates where changes have occurred.

Section of Photography. This section makes process negatives from chart drawings for the printing section, and matrices from chart drawings for the engravers. It furnishes reproductions of hydrographic and topographic field sheets and record books, geodetic and tidal computations, and performs all miscellaneous photographic work of the service.

The personnel of the division consists of a chief of division, an assistant chief, who is also a section chief, four section chiefs, ten clerks, thirty-four cartographers and draftsmen; seventeen engravers, twenty-seven lithographers, transferers, etc., one chart corrector, two photographers, five laborers, and one messenger.

Division of Tides and Currents. This division was created December 15, 1920, having previously been a section of the Division of Hydrography and Topography. Its work consists of tidal observations and computations; advance prediction of tides and currents, and the preparation of annual tidal and current tables; current observations and computations; tidal and current surveys of the principal harbors; physical oceanography, and the prepara-

tion of technical publications dealing with tides, currents, and related phenomena.

The office personnel of this division consists of a chief of division, three clerks, and twelve mathematicians. In the field there are from fourteen to twenty tide observers and from three to thirty current observers.

Division of Terrestrial Magnetism. This division has charge of the preparation of plans for the field operations governing the magnetic surveys; the direction and inspection of the parties in the field engaged in such surveys, and of the magnetic observatories; the office computations and discussion of the results of the magnetic work; and the maintenance of records of correspondence with such field parties and magnetic observatories.

The division has a chief, an assistant chief, a clerk, and three computers. In the field there are a hydrographic and geodetic engineer, and nine magnetic observers.

Division of Accounts. This division has charge of the disbursements and accounts of the Survey. All funds appropriated for the operation of the Survey are drawn from the Treasury on warrants, and accounts arising from the expenditures thereof, including the accounts of about fifty chiefs of party in the field, are examined and prepared for the approval of the Director. These chiefs of party operate large surveying parties afloat and ashore in all parts of the United States proper, its insular possessions, and Alaska, and their needs cover a wide range of expenditures. Advances of funds are made to them by the Disbursing Agent on requisition, and to him their accounts are submitted for examination, credit, and forwarding to the Department of Commerce for transmission to the general accounting office. It makes an annual statement of expenditures by appropriation, as required by statute, for inclusion in the annual report of the Secretary of Commerce, giving the payees' names, for what purpose paid, and the amount.

The personnel of this division consists of the Disbursing Agent, acting as chief of division, and a force of six clerks, four of whom are accountants.

CHAPTER IV

PERSONNEL

The personnel of the Coast and Geodetic Survey consists of commissioned officers with technical training; non-technical division and section chiefs; computers, draftsmen, and other highly skilled employees; clerks and stenographers; skilled and unskilled laborers; officers and crews of vessels; and a variable number of temporary employees in field parties. On March 1, 1922 there were 974 officers and employees in the service of the Coast and Geodetic Survey, exclusive of the last-mentioned group. Of these, 229 were on duty in Washington, seventeen at field stations, and 728 on field work.

The commissioned officers are appointed by the President by and with the advice and consent of the Senate. All the other officers and employees, except the employees on field parties and the crews of vessels, are appointed by the Secretary of Commerce from the lists of eligibles of the Civil Service Commission. The employees on field parties are appointed by the chiefs of parties, and the crews of vessels, by the commanding officers.

While the Coast and Geodetic Survey with all of its personnel is under the Department of Commerce, an act approved May 22, 1917 (40 Stat. L., 87), authorizes the President, by Executive Order in times of national emergency, to transfer to the service and jurisdiction of the War or Navy Departments "such vessels, equipment, stations, and personnel of the Coast and Geodetic Survey as he may deem to the best interest of the country," and provides that "any of the personnel of the Coast and Geodetic Survey who may be transferred as herein provided shall, while under the jurisdiction of the War Department or Navy Department, have proper military status and shall be subject to the laws, regulations, and orders for the government of the army and navy."

The commissioned officers receive the pay and allowances of naval officers of the same relative rank. The appropriation acts

fix the number that may be appointed to each grade. The salaries of all other office employees and the number in each position and at each salary, are specified by law. All other employees of the Coast and Geodetic Survey are paid out of lump sum appropriations.

Commissioned Personnel. Until the year 1920 all the employees of the Coast and Geodetic Survey had a civilian status, except that during the World War, under authority given the President by the act of May 22, 1917, a number of officers of the Survey were temporarily commissioned, as officers in the army and navy, in grades corresponding in salary to the positions held by them in the Survey. The act of May 18, 1920 (41 Stat. L., 603), gave the commissioned officers in addition to rank, the pay and allowances of naval officers holding the same relative ranks. There are no army or naval officers on detail with the Coast and Geodetic Survey.

The commissioned officers of the Survey, according to the appropriation act of March 4, 1921 (41 Stat. L., 1417), consist of the Director and two other Hydrographic and Geodetic Engineers, each with the relative rank of captain; seven Hydrographic and Geodetic Engineers with relative rank of commander, nine with relative rank of lieutenant commander, and thirty-eight with relative rank of lieutenant; fifty-five Junior Hydrographic and Geodetic Engineers with relative rank of lieutenant junior grade; and twenty-nine Aids with relative rank of ensign.

They are on duty in the Washington office and on land and sea duty in the field. They occupy the positions of chief, and assistant chief of technical divisions; chief of some technical sections; inspector in charge of stations; chief of field parties; and commander of vessels. They perform administrative and hydrographic, geodetic, and other scientific work.

Appointments and Promotions. The act of May 22, 1917 provides for the appointment of field officers of the Coast and Geodetic Survey by the President "by and with the advice and consent of the Senate." It classifies these officers into Hydrographic and Geodetic Engineers, Junior Hydrographic and Geodetic Engineers, and Aids. No person can be appointed an Aid, and no person can be promoted to a higher grade until he has passed a satisfactory mental and physical examination conducted in accor-

dance with regulation prescribed by the Secretary of Commerce.

The Director, who has the relative rank, pay, and allowances of a captain in the navy, is appointed to that position by the President, "by and with the advice and consent of the Senate," but he must be selected, according to the act of June 4, 1920 (41 Stat. L., 825), from the list of commissioned officers of the Survey not below the rank of commander. His appointment to this office is for a term of four years, but he may be reappointed for further four-year terms. The Assistant Director is required by the act of June 5, 1920 (41 Stat. L., 929), to be designated by the Secretary of Commerce from among the hydrographic and geodetic engineers.

The effect of these provisions is that appointments of commissioned officers are originally made to the lowest grade only, the higher grades, including the positions of Director and Assistant Director, being attainable only through promotion.

The regulations of the Survey, which have the approval of the Secretary of Commerce, provide that all Aids, that is, the lowest grade of commissioned officers, shall be appointed from the ranks of the junior field officers after at least six months' satisfactory service in these ranks and upon passing the required physical examination. In the case of promotions, officers are usually ordered for examination in the order of their rank. Failure to pass an examination for promotion does not involve dismissal, but simply continuation in the attained rank.

As the junior field officers are all originally appointed from an eligible list of the Civil Service Commission, it follows that the commissioned officers, although Presidential appointees, under the regulations begin their service as classified civil service employees.

The examinations for appointment and promotion in the grades of commissioned officers are conducted by a board of from three to five commissioned officers of the Survey, appointed by the Director, the ratings and marks fixed by the board being final. After a mental and physical examination, the successful candidates are certified for promotion.

Pay and Allowances. The act of May 18, 1920, provides that the commissioned officers of the Coast and Geodetic Survey shall receive the same pay and allowances as officers of the navy with whom they hold relative rank, including longevity, and that all laws relating to the retirement of commissioned officers of the

navy shall apply to commissioned officers of the Coast and Geodetic Survey.

The pay of the commissioned officers of the Coast and Geodetic Survey as well as those of the Public Health Service, Army, Navy, Marine Corps, and Coast Guard, are fixed by the act of June 10, 1922 (Public No. 235, 67th Congress). This act fixes the base pay according to periods of service, and in addition provides longevity pay, allowance for quarters when these are not furnished by the government, and allowance for subsistence. The base pay and the number of allowances are shown in table on opposite page.

The longevity pay is 5 per cent of the base pay for each three years up to thirty years of service, with the proviso that the base pay plus longevity for officers below the grade of Captain shall not exceed \$5,750. It also provides that the total of the base pay, longevity pay, and allowances for subsistence and rental of quarters shall not exceed \$7,200 except in the case of the Director of the Survey.

Each subsistence allowance is fixed at sixty cents a day for the fiscal year 1923, and it is provided that the value for subsequent years shall be fixed by the President in accordance with a certificate furnished by the Secretary of Labor showing the comparative retail cost of food as compared with the calendar year 1922.

The value of the allowance for one room is fixed at \$20 a month for the fiscal year 1923, and its value for future years is to be determined by the President in the same manner as the allowance for subsistence.

The allowances for subsistence and for rooms, as shown in the table, are greater for officers with dependents, which include the wife, unmarried children under 21 years of age, and the mother of the officer if she is in fact chiefly dependent on him for support.

Retirement. The act of May 18, 1920 provides that the laws relating to the retirement of commissioned officers of the navy shall apply to commissioned officers of the Coast and Geodetic Survey.

According to an act of May 13, 1908 (35 Stat. L., 127), the retirement age is sixty-four years, but when an officer has been thirty years in service or has become incapacitated for the performance of duties he may be retired from active service and placed upon the retired list.

Period	Officers receiving base rate at each period	Base rate of pay	Subsistence allowances for officers with dependents ^a	Allowance when quarters are not furnished	
				Officers with dependents	Officers without dependents
Sixth ...	Captains with 26 years service.	....	....	....	....
	Commanders with 30 years service.	\$4,000	2	6	4
Fifth ...	Captains not entitled to pay of sixth period.	....	....	....	....
	Commanders with 20 years service.	....	....	....	....
Fourth ..	Lieutenant Commanders with 23 years service.	3,500	3	6	4
	Commanders not entitled to pay of fifth or sixth period.	....	....	....	....
Third ...	Lieutenant commanders with 14 years service.	....	....	....	....
	Lieutenants with 17 years service.	3,000	3	5	3
Second ..	Lieutenant commanders not entitled to pay of fourth or fifth period.	....	....	....	....
	Lieutenants with 7 years service.	....	....	....	....
First	Lieutenants (junior grade) with 10 years service.	2,400	2	4	3
	Lieutenants not entitled to pay of third or fourth period.	....	....	....	....
First	Lieutenants (junior grade); with three years service.	....	....	....	....
	Ensigns with 5 years service.	2,000	2	3	2
First	All other commissioned officers.	1,500	1	2	2

^a An officer without dependents receives only one subsistence allowance regardless of period of service.

Officers on the retired list receive three-fourths of the pay of the grade or rank which they held at time of their retirement, if retired on account of age, length of service, or for incapacity resulting from an incident of the service. If retired for other reasons they receive either one-half pay of the grade or rank which they held at the time of their retirement, or one-half of the leave pay of such rank or grade, according to the cause for which they were retired. In computing retired pay, longevity is included.

An officer on the retired list while on active duty receives full duty pay and allowances.

Separations and Reductions. Commissioned officers may not be dismissed from the service or reduced in grade without investigation by a board of commissioned officers of the Survey ordered by the President of the United States or the Secretary of Commerce on the recommendation of the Director. The findings of such a board recommending the dismissal of a commissioned officer cannot be carried into execution until approved by the President of the United States. The separation or reduction of officers and employees in the classified service may be made by the Secretary of Commerce upon the recommendation of the Director, under provisions of the civil service rules.

Junior Field Officers. The junior field officers, from the ranks of which the commissioned officers are appointed, are the junior engineers and deck officers. The junior engineers are assigned as subordinate officers on parties engaged in geodetic operations, such as primary triangulation and traverse, precise leveling, astronomic determinations of latitude and longitude, determinations of intensity of gravity, etc. Deck officers are assigned to ships or to shore parties engaged in hydrographic and topographic surveys, triangulation and magnetic observations, or examinations of coastal waters with the wire drag. After promotion to commissioned rank these officers may be assigned to any class of duties, either ashore or afloat, irrespective of whether they served as junior engineers or as deck officers in the entrance grade.

Junior field officers are appointed by the Secretary of Commerce from a list of eligibles established by competitive examination conducted in accordance with the rules of the Civil Service Commission. In order to be eligible for the civil service examina-

tion candidates must be citizens of the United States between the ages of twenty and twenty-six years. A prerequisite for consideration for eligibility is that applicants must have completed at least three and one-half years of a course in civil engineering leading to the degree of B. S. or C. E. in a college, university, or technical school of recognized standing. Before appointment, following a successful examination, a candidate must have been graduated from a course in civil engineering with either of the above mentioned degrees. To be eligible for appointment he must also have successfully passed a physical examination conducted by a medical officer of the Public Health Service.

Other Classified Civil Service Employees. Persons occupying non-technical supervisory positions, such as the Chief Clerk, the Chief of the Division of Accounts, the chiefs of various administrative sections, and the positions of computers, draftsmen, clerks, stenographers, skilled workers, laborers, messengers and charwomen, are all originally appointed from the lists of eligibles of the Civil Service Commission, as in other bureaus.

In addition there are classes of employees whose work is of such a nature that they must have previous training and special fitness before being eligible for appointment. These are magnetic observers, marine engineers (motor), signalmen, dragmasters, mates, surgeons, and watch officers on board vessels. These employees are selected from lists of eligibles of the Civil Service Commission who have successfully passed non-assembled competitive examinations. Competitors for these positions are not required to appear for examination at any place. They are rated on the sworn statements of education, experience, etc., made on blanks furnished them, the statements being supplemented by correspondence with persons to whom the candidates have referred for their verification.

Unclassified Employees. In addition to the commissioned officers and the classified civil service employees, there is a large number of employees who on account of the peculiar nature of their occupations cannot conveniently be brought into the classified civil service. These are the members of crews of vessels and the hands attached to field parties.

The members of crews of the Survey who come within this group of employees are the boatswains, coxswains to power launches, masters-at-arms, quartermasters, sailors, assistant engineers, oilers, firemen, radio operators, writers, stewards, pharmacists, cooks, mess attendants, and carpenters.

These employees are shipped by the commanding officers of the vessels, the contract of employment being usually for one year. Upon being shipped, recruits are required to sign the book of shipping articles on board the vessel. The Coast and Geodetic Survey has no authority to bind these men by enlistment, as is done in the navy.

The rate of pay varies according to the position and the coast of the United States in whose waters the vessels are operating. In addition to the pay, a daily ration is allowed, and a mess is operated on board.

Officers and seamen on vessels of the Coast and Geodetic Survey are entitled to the benefits of the Public Health Service under the regulations which govern the treatment of seamen on documented vessels.

The field hands and other employees of the Survey, such as recorders, chainmen, rodmen, lightkeepers, operators of gas engines, etc., who are not appointed through the Civil Service Commission, are hired by the chiefs of parties, generally in the localities in which the parties are operating. The rate of pay varies according to the locality of the work and the class of service performed. No examinations are required for these positions.

APPENDIX I

OUTLINE OF ORGANIZATION

EXPLANATORY NOTE

The Outlines of Organization in this series of monographs have for their purpose to make known in detail the organization and personnel possessed by the several services of the national government to which they relate. They have been prepared in accordance with the plan followed by the President's Commission on Economy and Efficiency in the preparation of its outlines of the organization of the United States government.¹ They differ from those outlines, however, in that whereas the commission's report showed only organization units, the presentation herein has been carried far enough to show the personnel embraced in each organization unit.

These outlines are of value not merely as an effective means of making known the organization of the several services. If kept revised to date by the services, they constitute exceedingly important tools of administration. They permit the directing personnel to see at a glance the organization and personnel at their disposition. They establish definitely the line of administrative authority and enable each employee to know his place in the system. They furnish the essential basis for making plans for determining costs by organization division and subdivision. They afford the data for a consideration of the problem of classifying and standardizing personnel and compensation. Collectively, they make it possible to determine the number and location of organization divisions of any particular kind, as, for example, laboratories, libraries, blue-print rooms, or any other kind of plant possessed by the national government, to what services they are attached and where they are located, or to determine what services are maintaining stations at any city or point in the United States. The Institute hopes that upon the completion of the present series, it will be

¹ House Doc. 458, 62nd, Congress, 2nd Session, 1912, 2 vols.

able to prepare a complete classified statement of the technical and other facilities at the disposal of the government. The present monographs will then furnish the details regarding the organization, equipment, and work of the institutions so listed and classified.

OUTLINE OF ORGANIZATION

COAST AND GEODETIC SURVEY DEPARTMENT OF COMMERCE MARCH 1, 1922

<i>Organization Units; Classes of Employees</i>	<i>Number</i>	<i>Salary Rate</i>
1. Office of the Director		
Director	1	^a
Clerk	1	\$1,800
Messenger	1	820
2. Office of the Assistant Director		
1. Office proper		
Assistant Director	1	^a
2. Instrument Section		
Chief of Section	1	3,000
Clerk	1	1,650
	1	1,200
	1	1,000
Instrument Maker	1	1,800
	1	1,600
	5	1,400
Pattern Maker	3	1,400
Laborer	1	720
	1	700
3. Office of the Chief Clerk		
1. Office proper of the Chief Clerk		
Chief Clerk	1	2,500
Clerk	1	1,800
Clerk	1	1,000
Carpenters and Painter	2	900
Engineer	1	1,800
Electrician	1	1,400
	1	1,080
Electrotyper	1	1,200
Dynamo Tender	3	1,080
Plumber and Steamfitter	1	1,200
Watchman	2	880
	1	840
	1	820

^a Pay and allowances of Captain, navy.

OUTLINE OF ORGANIZATION

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Messenger	I	880
	I	840
Laborer	I	820
	2	700
Extra Laborer (Chief Painter)	I	1,320
Extra Laborer (Charwoman)	8	260
Telephone Operator	I	900
	I	720
2. Library and Archives		
Chief of Section	I	1,800
Clerk	3	1,000
Laborer	I	700
Extra Laborer	I	550
3. Supplies and Shipments Section		
Chief of Section	I	1,650
Clerk	2	1,200
Clerk	I	1,000
Laborer	I	840
4. Personnel Section		
Chief of Section	I	1,200
Clerk	I	1,400
4. Division of Geodesy		
Chief of Division	I	^a
Assistant Chief of Division	I	^b
Clerk	I	1,400
	I	1,200
Hydrographic and Topographic Drafts-		
man	I	1,400
Computer	I	2,460
	I	2,360
	3	2,260
	3	2,060
	2	1,800
	2	1,600
	5	1,400
5. Division of Hydrography and Topography		
1. Office of Chief of Division		
Chief of Division	I	^c
Clerk	I	1,400
	I	1,200
	I	1,000
2. Field Work Section		
Assistant Chief of Division in Charge	I	^b

^b Pay and allowances of Lieutenant Commander, navy.

^c Pay and allowances of Commander, navy.

3.	Vessels and Equipment Section		
	Chief of Section	I	^b
	Hull Draftsman	I	1,560
4.	Coast Pilot Section		
	Chief of Section	I	^d
5.	Coast Surveys, Manila		
	Director	I	^d
	Draftsman	2	3,000
		I	2,000
	Clerk (Chief Clerk)	I	1,800
	Chief of the Division of Photo-lithog- raphy	I	3,000
	Computer	I	3,000
6.	Field Station, Seattle		
	Inspector in Charge	I	^d
	Skilled Laborer and Tide Observer	I	1,200
	Clerk	I	1,200
7.	Field Station, San Francisco, Calif.		
	Inspector in Charge	I	^e
	Skilled Laborer and Tide Observer	I	1,500
8.	Field Station, Boston		
	Inspector in Charge	I	^e
	Clerk and Tide Observer	I	1,380
9.	Field Station, New York		
	Inspector in Charge	I	^e
	Clerk	I	1,200
10.	Field Station, New Orleans		
	Hydrographic and Geodetic Engineer in Charge	I	^f
6.	Division of Charts		
1.	Office of Chief of Division		
	Chief of Division	I	^d
	Clerk	I	1,400
		I	1,000
	Laborer	I	720
2.	Field Record Section		
	Assistant Chief of Division	I	^g
	Hydrographic and Topographic Drafts- man	I	2,460

^d Pay and allowances of Commander, navy.

^e Pay and allowances of retired Lieutenant Commander, navy, recalled to active duty.

^f Pay and allowances of retired Commander, navy, recalled to active duty.

^g Pay and allowances of Lieutenant, navy.

3. Drafting Section		
Chief of Section	1	2,900
Hydrographic and Topographic Drafts-		
man	1	2,900
	2	2,460
	6	2,260
	6	2,060
	3	1,800
	6	1,600
	2	1,400
Laborer	1	840
Chart Corrector	1	1,800
4. Printing and Sales Section		
Chief of Section	1	2,000
Clerk	1	1,800
	3	1,200
Clerk	3	1,000
	1	900
Hydrographic and Topographic Drafts-		
man	3	1,400
	4	1,200
Lithographer, Lithographic Draftsman,		
Transferer, Lithographic Pressman,		
etc.	2	2,200
	2	2,000
	2	1,900
	2	1,800
	3	1,600
	8	1,400
	2	1,200
	1	1,100
	5	900
Laborer	1	840
	1	820
	1	720
5. Engraving Section		
Chief of Section	1	2,500
Engraver	2	2,400
	3	2,200
	3	2,000
	2	1,800
	2	1,600
	3	1,400
	2	1,000
Messenger	1	840

6. Photograph Section		
Chief of Section	I	1,700
Photographer	I	1,600
	I	1,200
7. Division of Tides and Currents		
Chief of Division	I	^h
Clerk	2	1,000
	I	900
Computer	2	2,460
	I	2,360
	2	1,800
	2	1,600
	6	1,400
8. Division of Terrestrial Magnetism		
Chief of Division	I	ⁱ
Assistant Chief of Division	I	3,000
Clerk	I	1,000
Computer	I	2,060
	2	1,600
9. Division of Accounts		
Chief of Division	I	3,000
Clerk	I	1,800
	I	1,650
	2	1,200
	I	1,000
	I	900
10. Field Establishment		
1. Geodetic Work		
Hydrographic and Geodetic Engineer	I	^h
	3	^j
Junior Hydrographic and Geodetic Engineer	8	^k
Junior Engineer	I	2,000
Signalman	I	3,000
	I	1,500
Extra Observer	I	1,200
Hands engaged in rodding, chaining, recording, heliotroping, etc., on field parties	¹	<i>Per month</i> \$100 to \$160

^h Pay and allowances of Lieutenant Commander, navy.

ⁱ Pay and allowances of Commander, navy.

^j Pay and allowances of Lieutenant, navy.

^k Pay and allowances of Lieutenant (Junior Grade), navy.

¹ Number required during the field season, within the limit of the appropriation authorized.

2. Hydrographic and Topographic Work

Hydrographic and Geodetic Engineer	1	m
	4	n
	34	o
Junior Hydrographic and Geodetic Engineer	47	p
Aid	29	q
Deck Officer	11	2,000
Chief Engineer	1	2,040
	3	1,920
	4	1,800
	2	1,740
	1	1,680
	1	1,500
Mate	1	1,800
	1	1,680
	2	1,560
	1	1,380
Surgeon	3	1,200
Watch Officer	1	1,680
Draftsman	4	900
Dragmaster	2	1,680
Marine Engineer (Motor)	3	1,680
<i>Per month</i>		
Engineer	57	\$35.00 to \$160
Fireman	68	13.20 to 90
Boatswain	22	21.20 to 120
Carpenter	10	35.00 to 110
Coxswains to Power Launches	8	35.00 to 95
Master-at-Arms	6	40.00 to 95
Quartermaster	50	15.20 to 100
Seaman	179	11.20 to 90
Writer	18	35.00 to 125
Wireless Operator	23	30.00 to 120
Pharmacist	1	100
Cook	35	13.20 to 100
Mess Attendant	40	15.00 to 50
Steward	17	35.00 to 100

^m Pay and allowances of Commander, navy.

ⁿ Pay and allowances of Lieutenant Commander, navy.

^o Pay and allowances of Lieutenant, navy.

^p Pay and allowances of Lieutenant (Junior Grade), navy.

^q Pay and allowances of Ensign, in navy.

3. Magnetic Work		
Hydrographic and Geodetic Engi- neer	1	^r
Magnetic Observer	2	1,980
	4	1,740
	3	1,500
4. Tides and Currents Work	1	900
Tide Observer	1	900
	3	300
	7	240
	1	180

^r Pay and allowances of retired Commander in navy, recalled to active duty.

APPENDIX 2

CLASSIFICATION OF ACTIVITIES

EXPLANATORY NOTE

The Classifications of Activities in this series have for their purpose to list and classify in all practicable detail the specific activities engaged in by the several services of the national government. Such statements are of value from a number of standpoints. They furnish, in the first place, the most effective showing that can be made in brief compass of the character of the work performed by the service to which they relate. Secondly, they lay the basis for a system of accounting and reporting that will permit the showing of total expenditures classified according to activities. Finally, taken collectively, they make possible the preparation of a general or consolidated statement of the activities of the government as a whole. Such a statement will reveal in detail, not only what the government is doing, but the services in which the work is being performed. For example, one class of activities that would probably appear in such a classification is that of "scientific research." A subhead under this class would be "chemical research." Under this head would appear the specific lines of investigation under way and the services in which they were being prosecuted. It is hardly necessary to point out the value of such information in planning for future work and in considering the problem of the better distribution and coördination of the work of the government. The institute contemplates attempting such a general listing and classification of the activities of the government upon the completion of the present series.

CLASSIFICATION OF ACTIVITIES

1. Administration
2. Hydrographic Work
 1. Topographic Surveys
 2. Hydrographic Surveys

3. Ocean Current and Tidal Observations
4. Preparation of Nautical Charts and Coast Pilots
5. Oceanography
3. Geodetic Work
 1. Triangulation
 2. Traverse
 3. Leveling
 4. Gravity Measurements
 5. Determining the Figure of the Earth
4. Magnetic Observations
5. Astronomic Work: Ascertaining
 1. Time
 2. Latitude
 3. Longitude
 4. Azimuth
6. Seismological Observations

APPENDIX 3

PUBLICATIONS

The results of the work of the Coast and Geodetic Survey are published in annual reports; charts upon various scales, including sailing charts, general charts of the coast and harbor charts; tide tables issued annually in advance; coast pilots, with sailing directions covering navigable waters; notices to mariners (issued every week jointly by the Coast and Geodetic Survey and the Bureau of Lighthouses), containing current information necessary for safe navigation; publications on the subjects of astronomy, geodesy, topography, hydrography, terrestrial magnetism, the tides and related subjects; and instructions and other information concerning the work of the Survey.

Annual Report. Annual reports have been issued in 1816, and from 1834 to 1922 inclusive. They give an account of the work accomplished in each division of the Washington office and in the field; a statement of the present condition of each of the various surveys; maps and diagrams showing the condition of field operations; and, in earlier reports, appendices on scientific and technical subjects.

Charts. The Survey publishes 659 charts on different scales, for general or local use, including coast and harbor charts covering the coasts of the United States and Alaska, Porto Rico, the Virgin Islands, the Canal Zone, Hawaii, and the Philippine Islands; also magnetic variation charts of the United States, the West Indies, Alaska, and the Philippine Islands.

Tide Tables. General Tide Tables are issued annually in advance, giving the times and heights of high and low water for the principal ports of the world. Tide tables for the Atlantic and Pacific coasts of North America are also issued separately.

Coast Pilots. Twelve Coast Pilot volumes are issued, giving sailing directions covering the navigable waters of the Atlantic, Gulf, and Pacific coasts, Porto Rico and the Virgin Islands, the

coast of Alaska and of the Philippine Islands. In addition, there are published two volumes of sailing directions for the Philippine Islands and a volume of coast pilot notes relating to Hawaii. Inside Route Pilots have been published covering the navigable waters from New York to Key West to New Orleans, and the coast of New Jersey.

Notices to Mariners. A "Weekly Notices to Mariners" is issued jointly by the Coast and Geodetic Survey and the Bureau of Lighthouses. It contains the latest corrections to aids to navigation, reports of recently discovered dangers, and a list of new charts and other publications relating to navigation, new editions of charts, and canceled charts.

Other Publications. A mass of other scientific and professional information has been published by the Coast and Geodetic Survey in book and pamphlet form. These publications may be grouped under the general heads of geodesy, hydrography, topography, terrestrial magnetism, cartography, digests of geodetic publications, and miscellaneous.

The scientific and professional publications give the results of the Survey's geodetic, hydrographic, topographic, and magnetic work. Among other data, they furnish geographic positions, elevations, depths of water, data concerning changes in coast line or in depths in channels and harbors, and information relating to terrestrial magnetism, in convenient form for the use of engineers, surveyors, railroad officers, state and municipal governments, other departments of the national government, and others engaged in work of development, construction, or improvement.

Among the miscellaneous publications are pamphlets of instruction and tables for use in the practical work of surveying and map making and other field work of the Survey, and popular information concerning the work of the service.

All the publications of the Coast and Geodetic Survey issued up to and including the year 1908 are listed in a work entitled: "List and Catalogue of the Publications issued by the U. S. Coast and Geodetic Survey 1816-1902." Reprint with Supplement, 1903-1908. Lists of subsequent publications may be found in "List of Publications of the Department of Commerce Available for Distribution" issued once each year and in the "Monthly List of Publications issued by the Department of Commerce."

The Survey also issues a catalogue of charts, Coast Pilots, Inside Route Pilots, and Tide Tables, a separate list of charts being issued for the Philippine Islands.

Digests (one for each state) of the geodetic publications issued by the Survey are being prepared. In these are shown, in alphabetical order, the stations established in each county in the state for which the digest is made, with a reference to the publication of the results and page of the publication in which it will be found.

APPENDIX 4

LAWS

(A) INDEX TO LAWS

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(B) COMPILATION OF LAWS

1807—Act of February 10, 1807 (2 Stat. L., 413)—An Act To provide for surveying the coasts of the United States.

[SEC. 1.] That the President of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.

SEC. 2. That it shall be lawful for the President of the United States to cause such examinations and observations to be made, with respect to St. George's bank, and any other bank or shoal and the soundings and currents beyond the distance aforesaid to the Gulf Stream, as in his opinion may be especially subservient to the commercial interests of the United States.

SEC. 3. That the President of the United States shall be, and he is hereby authorized and requested, for any of the purposes aforesaid, to cause proper and intelligent persons to be employed, and also such of the public vessels in actual service, as he may judge expedient, and to give such instructions for regulating their conduct as to him may appear proper, according to the tenor of this act.

SEC. 4. That for carrying this act into effect there shall be, and hereby is appropriated, a sum not exceeding fifty thousand dollars, to be paid out of any monies in the treasury, not otherwise appropriated.

1832—Act of July 10, 1832 (4 Stat. L., 570)—An Act To carry into effect the act to provide for a survey of the coast of the United States.

[SEC. 1.] That for carrying into effect the act, entitled "An act to provide for surveying the coasts of the United States," approved on the

tenth day of February, one thousand eight hundred and seven, there shall be, and hereby is, appropriated, a sum not exceeding twenty thousand dollars, to be paid out of any money in the treasury not otherwise appropriated; and the said act is hereby revived, and shall be deemed to provide for the survey of the coasts of Florida, in the same manner as if the same had been named therein.

SEC. 2. That the President of the United States be, and he is hereby authorized, in and about the execution of the said act, to use all maps, charts, books, instruments, and apparatus, which now, or hereafter may belong to the United States, and employ all persons in the land or naval service of the United States, and such astronomers and other persons as he shall deem proper.

1843—Act of March 3, 1843 (5 Stat. L., 630, 640)—An Act Making appropriations for the civil and diplomatic expenses of Government for the fiscal year ending the thirtieth day of June, eighteen hundred and forty-four.

[SEC. 1.] . . . That this, and all other appropriations hereafter to be made for this work, shall, until otherwise provided by law, be expended in accordance with a plan of reorganizing the mode of executing the survey, to be submitted to the President of the United States by a board of officers which shall be organized by him, to consist of the present superintendent, his two principal assistants, and the two naval officers now in charge of the hydrographical parties, and four from among the principal officers of the corps of topographical engineers; none of whom shall receive any additional compensation whatever for this service, . . . And the President of the United States shall adopt and carry into effect the plan of said board, as agreed upon by a majority of its members; and the plan of said board shall cause to be employed as many officers of the army and navy of the United States as will be compatible with the successful prosecution of the work; the officers of the navy to be employed on the hydrographical parts, and the officers of the army on the topographical parts of the work; and no officer of the army or navy shall hereafter receive any extra pay out of this, or any future appropriations for surveys.

1844—Act of June 17, 1844 (5 Stat. L., 681, 691)—An Act Making appropriations for the civil and diplomatic expenses of Government for the fiscal year ending the thirtieth day of June, eighteen hundred and forty-five, and for other purposes.

[SEC. 1.] . . . That officers of the army and navy shall, as far as practicable, be employed in the work, whenever and in the manner required by the department having charge thereof.

1853—Act of March 3, 1853 (10 Stat. L., 189, 209). An Act Making appropriations for the civil and diplomatic expenses of Government for the year ending the thirtieth of June, eighteen hundred and fifty-four.

* * * *

SEC. 2. That . . . it shall be the duty of the Secretary of the Treasury [Commerce¹] annually to report to Congress, during the first month of each regular session, the number and names of the persons employed during the last preceding fiscal year upon the coast survey and business connected therewith; the amount of compensation of every kind respectively paid them, for what purpose, and the length of time employed; further, to report a full statement of all other expenditures made under the direction of the Superintendent of the Coast Survey.

1853—Act of March 3, 1853 (10 Stat. L., 214, 217)—An Act Making appropriations for the support of the Army for the year ending the thirtieth of June, one thousand eight hundred and fifty-four.

[SEC. 1.] . . . That the annual coast survey report shall be submitted to Congress during the month of December in each year, and shall be accompanied by a general chart of the whole coasts of the United States, on as large a scale as convenient and practicable, showing, as near as practicable, the configuration of the coasts, and showing, by lines, the probable limits of the Gulf Stream, and showing, by lines, the probable limit to which the soundings off the coast will extend, and showing, by the use of colors and explanations, the exact portions of our coasts, of which complete charts have been published by the Coast Survey; also, showing such other parts of the coasts of which the triangulation, the topography, and the soundings have been completed, but not published and, also such parts of the coasts of which the triangulation and topography, or the triangulation only, have been completed.

1858—Act of June 12, 1858 (11 Stat. L., 319, 320)—An Act Making appropriation for sundry civil expenses of the Government for the year ending the thirtieth of June, eighteen hundred and fifty-nine.

[SEC. 1.] . . . That the Secretary of the Treasury [Commerce¹] may make such allowances to the officers and men of the army and navy, while employed on Coast Survey Service, for subsistence, in addition to their compensation, as he may deem necessary, not exceeding the sum authorized by the Treasury regulation of the eleventh of May, eighteen hundred and forty-four.

¹ Acts of February 14, 1903, and March 4, 1913.

1879—Act of March 3, 1879 (20 Stat. L., 377, 394)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and eighty, and for other purposes.

[SEC. 1.] . . . All collections of rocks, minerals, soils, fossils, and objects of natural history, archæology, and ethnology, made by the Coast and Interior Survey . . . when no longer needed for investigations in progress shall be deposited in the National Museum.

1879—Act of June 28, 1879 (21 Stat. L., 37)—An Act To provide for the appointment of a "Mississippi River Commission" for the improvement of said river from the head of the passes near its mouth to its headwaters.

* * * *

SEC. 2. The President of the United States shall, by and with the advice and consent of the Senate, appoint seven commissioners, three of whom shall be selected from the Engineer Corps of the Army, one from the Coast and Geodetic Survey, and three from civil life, two of whom shall be civil engineers. And any vacancy which may occur in the commission shall in like manner be filled by the President of the United States; and he shall designate one of the commissioners appointed from the Engineer Corps of the Army to be president of the commission. The commissioners appointed from . . . the Coast and Geodetic Survey shall receive no other pay or compensation than is now allowed them by law, . . .; and the commissioners appointed under this act shall remain in office subject to removal by the President of the United States.

SEC. 3. It shall be the duty of said commission to direct and complete such surveys of said river, between the Head of the Passes near its mouth to its headwaters as may now be in progress, and to make such additional surveys, examinations, and investigations, topographical, hydrographical, and hydrometrical, of said river and its tributaries, as may be deemed necessary by said commission to carry out the objects of this act. And to enable said commission to complete such surveys, examinations, and investigations . . . the Secretary of the Treasury [Commerce²] shall, when requested by said commission . . . detail from the Coast and Geodetic Survey such officers and men as may be necessary, and shall place in the charge and for the use of said commission such vessel or vessels and such machinery and instruments as may be under his control and may be deemed necessary. . . .

1886—Act of August 4, 1886 (24 Stat. L., 222, 255)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and eighty-seven, and for other purposes.

² Acts of February 14, 1903, and March 4, 1913.

[SEC. 1.] . . . That all printing and engraving for . . . the Coast and Geodetic Survey, . . . shall hereafter be estimated for separately and in detail, and appropriated for separately. . . .

1890—Act of August 30, 1890 (26 Stat. L., 371, 382)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, and for other purposes.

[SEC. 1.] . . . Nor shall there hereafter be made any allowance for subsistence to officers of the navy attached to the Coast and Geodetic Survey, except that when officers are detached to do work away from their vessels under circumstances involving them in extra expenditures, the Superintendent [Director³] may allow to any such officer subsistence at a rate not exceeding one dollar per day for the period actually covered by such duty away from such vessel.

1895—Act of January 12, 1895 (28 Stat. L., 601, 613, 620)—An Act Providing for the public printing and binding and the distribution of public documents, as amended by Joint Resolution of April 20, 1896 (29 Stat. L., 471).

* * * *

SEC. 73. Extra copies of documents and reports shall be printed promptly when the same shall be ready for publication, and shall be bound in paper or cloth as directed by the Joint Committee on Printing, and shall be of the number following in addition to the usual number:

* * * *

Of the Report of the Superintendent [Director³] of the Coast and Geodetic Survey, *two thousand eight hundred copies in quarto form, bound in one volume, two hundred for the Senate, and six hundred for the House, and two thousand for distribution by the Coast and Geodetic Survey* (as amended).

* * * *

SEC. 76. The charts published by the Coast and Geodetic Survey shall be sold at cost of paper and printing as nearly as practicable; and there shall be no free distribution of such charts except to the departments and officers of the United States requiring them for public use; and a number of copies of each sheet, not to exceed three hundred, to be presented to such foreign governments, libraries, and scientific associations, and institutions of learning as the Secretary of the Treasury [Commerce⁴] may direct; but on the order of senators, representatives, and delegates not to exceed ten copies to each may be distributed through the Superintendent of the Coast and Geodetic Survey.

* * * *

SEC. 89. . . . No report, publication, or document shall be printed in excess of the number of one thousand of each in any one fiscal year without

³ Act of June 5, 1920.

⁴ Acts of February 14, 1903, and March 4, 1913.

authorization therefore by Congress, except that . . . of the reports of chiefs of bureaus without appendices there may be printed in any one fiscal year not to exceed two thousand five hundred copies, bound in pamphlet form; *Provided*, That . . . the Secretary of the Treasury [Commerce⁴] may authorize the printing of the notices to mariners, tide tables, coast pilots, bulletins, and other special publications of the Coast and Geodetic Survey . . . in such editions as the interests of the Government and of the public may require.

1901—Act of March 3, 1901 (31 Stat. L., 1133, 1144)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and two, and for other purposes.

[SEC. 1.] . . . And hereafter the Secretary of the Treasury [Commerce⁴] is authorized to purchase, from the appropriation for the United States Coast and Geodetic Survey, provisions, clothing and small stores for the enlisted men, and food supplies for field parties working in remote localities, such provisions, clothing and small stores, and food supplies to be sold to the employees of said survey and the appropriation reimbursed. . . .

1903—Act of February 14, 1903 (32 Stat. L., 825, 826)—An Act To establish the Department of Commerce and Labor, as amended by Act of March 4, 1913 (37 Stat. L., 736).

* * * *

SEC. 4. That the following named . . . bureaus . . . of the public service, now and heretofore under the jurisdiction of the Department of the Treasury, and all that pertains to the same, known as . . . the Coast and Geodetic Survey . . . , be, and the same hereby are transferred from the Department of the Treasury to the Department of Commerce, and the same shall hereafter remain under the jurisdiction and supervision of the last-named Department.

1907—Act of March 4, 1907 (34 Stat. L., 1295, 1322)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and eight, and for other purposes.

[SEC. 1.] . . . Scientific and other employees of the United States Coast and Geodetic Survey, while employed outside of the District of Columbia, are hereby authorized to make assignments of their pay, under such regulations as the Secretary of Commerce . . .⁵ may prescribe.

⁴ Acts of February 14, 1903, and March 4, 1913.

1909—Act of March 4, 1909 (35 Stat. L., 945, 974)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and ten, and for other purposes.

[SEC. 1.] . . . The Secretary of Commerce . . .⁵ at his discretion, may hereafter grant to officers of the field force of the Coast and Geodetic Survey on duty in the Philippine Islands, at one time the whole or any portion of the annual leave accrued and unused during a period of three years.

1910—Act of June 25, 1910 (36 Stat. L., 630, 658)—An Act Making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes.

[SEC. 1.] . . . That from and after the date of the approval of this act the members of said [Mississippi River] commission appointed from the Coast and Geodetic Survey shall receive the same annual compensation as other civilian members of said commission, and the excess of said compensation over and above the compensation he receives from the Coast and Geodetic Survey shall be paid from the funds of said commission.

1914—Act of August 1, 1914 (38 Stat. L., 609, 661)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and fifteen, and for other purposes.

[SEC. 1.] . . . The Secretary of Commerce is authorized to transfer to the Smithsonian Institution such instruments of the Coast and Geodetic Survey as in his judgment are of historic value but of no further use in the Survey's work.

1916—Act of July 1, 1916 (39 Stat. L., 262, 320)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and seventeen, and for other purposes.

* * * *

Charts of the Coast Survey that are obsolete and have been superseded by charts containing more advanced information based on the most recent surveys, may be distributed free to educational institutions, each of such charts to have stamped or printed conspicuously thereon the words "For school use only."

⁵ Act of March 4, 1913.

1917—Act of March 3, 1917 (39 Stat. L., 1047, 1055)—An Act Making appropriations for the Diplomatic and Consular Service for the fiscal year ending June thirtieth, nineteen hundred and eighteen.

* * * *

The duly appointed representative of the United States on the permanent commission of the International Geodetic Association is hereby granted authority to vote with the representatives on the permanent commission from other nations on all matters coming before the association, including the extension of its existence subject to the approval of Congress.

1917—Act of May 22, 1917 (40 Stat. L., 84, 87). An Act To temporarily increase the commissioned and warrant and enlisted strength of the Navy and Marine Corps, and for other purposes.

* * * *

SEC. 16. That the President is hereby authorized, whenever in his judgment a sufficient national emergency exists, to transfer to the service and jurisdiction of the War Department, or of the Navy Department, such vessels, equipment, stations, and personnel of the Coast and Geodetic Survey as he may deem to the best interest of the country, and after such transfer all expenses connected therewith shall be defrayed out of the appropriations for the department to which transfer is made: *Provided*, That such vessels, equipment, stations, and personnel shall be returned to the Coast and Geodetic Survey when such national emergency ceases, in the opinion of the President, and nothing in this act shall be construed as transferring the Coast and Geodetic Survey or any of its functions from the Department of Commerce except in time of national emergency and to the extent herein provided: *Provided further*, That any of the personnel of the Coast and Geodetic Survey who may be transferred as herein provided shall, while under the jurisdiction of the War Department or Navy Department, have proper military status and shall be subject to the laws, regulations, and orders for the government of the army or navy, as the case may be, in so far as the same may be applicable to persons whose retention permanently in the military service of the United States is not contemplated by law: *And provided further*, That the President is authorized to appoint, by and with the advice and consent of the Senate, the field officers of the Coast and Geodetic Survey, who are now officially designated assistants and aids, as follows: Officers now designated assistants and receiving a salary of \$2,000 or more per annum shall be appointed hydrographic and geodetic engineers; officers now designated assistants and receiving a salary of \$1,200 or greater but less than \$2,000 per annum shall be appointed junior hydrographic and geodetic engineers; officers now designated aids shall be appointed aids: *Provided*, That no person shall be appointed aid or shall be promoted from aid to junior hydrographic and geodetic engineer or from junior hydrographic and geodetic engineer to hydrographic and geodetic engineer until after passing a satisfactory mental and physical examination conducted in accordance with regulations pre-

scribed by the Secretary of Commerce, except that the President is authorized to nominate for confirmation the assistants and aids in the service on the date of the passage of this act.

Nothing in this act shall reduce the total amount of pay and allowances they were receiving at the time of transfer. While actually employed in active service under direct orders of the War Department or of the Navy Department members of the Coast and Geodetic Survey shall receive the benefit of all provisions of laws relating to disability incurred in line of duty or loss of life.

When serving with the army or navy the relative rank shall be as follows:

Hydrographic and geodetic engineers receiving \$4,000 or more shall rank with and after colonels in the army and captains in the navy.

Hydrographic and geodetic engineers receiving \$3,000 or more but less than \$4,000 shall rank with and after lieutenant colonels in the army and commanders in the navy.

Hydrographic and geodetic engineers receiving \$2,500 or more but less than \$3,000 shall rank with and after majors in the army and lieutenant commanders in the navy.

Hydrographic and geodetic engineers receiving \$2,000 or more but less than \$2,500 shall rank with and after captains in the army and lieutenants in the navy.

Junior hydrographic and geodetic engineers shall rank with and after first lieutenants in the army and lieutenants (junior grade) in the navy.

Aids shall rank with and after second lieutenants in the army and ensigns in the navy.

And nothing in this act shall be construed to affect or alter their rates of pay and allowances when not assigned to military duty as hereinbefore mentioned.

The Secretary of War, the Secretary of the Navy, the Secretary of Commerce shall jointly prescribe regulations governing the duties to be performed by the Coast and Geodetic Survey in time of war and for the coöperation of that service with the War and Navy departments in time of peace in preparation for its duties in war, which regulations shall not be effective unless approved by each of the said Secretaries, and included therein may be rules and regulations for making reports and communications between the officers or bureaus of the War and Navy departments and the Coast and Geodetic Survey.

1917—Act of October 6, 1917 (40 Stat. L., 393)—An Act To provide for the service of officers of auxiliary naval forces on naval courts.

[SEC. 1.] That when actively serving under the Navy Department in time of war or during the existence of an emergency, pursuant to law, as a part of the naval forces of the United States, commissioned officers of the Naval Reserve Force, Marine Corps Reserve, National Naval Volunteers, Naval Militia, Coast Guard, Lighthouse Service, Coast and Geodetic Survey, and Public Health Service are hereby empowered to serve on naval courts-martial and deck courts under such regulations necessary for the proper administration of justice and in the interests of the services involved, as may be prescribed by the Secretary of the Navy.

1918—Act of July 1, 1918 (40 Stat. L., 634, 688)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and nineteen, and for other purposes.

[SEC. I.] . . . That advances of money from available appropriations hereafter may be made to the Coast and Geodetic Survey and by authority of the superintendent thereof to chiefs of parties, who shall give bond under such rules and regulations and in such sum as the Secretary of Commerce may direct, and accounts arising under such advances shall be rendered through and by the disbursing officer of the Coast and Geodetic Survey to the Treasury Department as under advances heretofore made to chiefs of parties.

1920—Act of May 18, 1920 (41 Stat. L., 601, 603)—An Act To increase the efficiency of the commissioned and enlisted personnel of the Army, Navy, Marine Corps, Coast Guard, Coast and Geodetic Survey, and Public Health Service.

[SEC. I.] That, commencing January 1, 1920, commissioned officers of the Army, Navy, and Marine Corps, and Public Health Service shall be paid, in addition to all pay and allowances now allowed by law, increases at rates per annum as follows: Colonels in the Army and Marine Corps, captains in the Navy, and assistant surgeons general in the Public Health Service, \$600; lieutenant colonels in the Army and Marine Corps, commanders in the Navy, and senior surgeons in the Public Health Service, \$600; majors in the Army and Marine Corps, lieutenant commanders in the Navy, and surgeons in the Public Health Service, \$840; captains in the Army and Marine Corps, lieutenants in the Navy, and passed assistant surgeons in the Public Health Service, \$720; first lieutenants in the Army and Marine Corps, lieutenants (junior grade), acting assistant surgeons and acting assistant dental surgeons in the Navy, and assistant surgeons in the Public Health Service, \$600; second lieutenants in the Army and Marine Corps, and ensigns in the Navy, \$420: *Provided*, That contract surgeons of the Army serving full time shall receive the pay of a second lieutenant.

* * * *

SEC. II. That in lieu of compensation now prescribed by law, commissioned officers of the Coast and Geodetic Survey shall receive the same pay and allowances as now are or hereafter may be prescribed for officers of the Navy with whom they hold relative rank as prescribed in the act of May 22, 1917, entitled "An Act to Temporarily Increase the Commissioned and Warrant and Enlisted Strength of the Navy and Marine Corps, and for Other Purposes," including longevity, and all laws relating to the retirement of commissioned officers of the Navy shall hereafter apply to commissioned officers of the Coast and Geodetic Survey: *Provided*, That hereafter longevity pay for officers in the Army, Navy, Marine Corps,

Coast Guard, Public Health Service, and Coast and Geodetic Survey shall be based on the total of all service in any or all of said services.

SEC. 12. That hereafter when any commissioned officer, non-commissioned officer of the grade of color sergeant and above, including any non-commissioned officer of the Marine Corps of corresponding grade, warrant officer, chief petty officer, or petty officer (first class), having a wife or dependent child or children, is ordered to make a permanent change of station, the United States shall furnish transportation in kind from funds appropriated for the transportation of the Army, the Navy, the Marine Corps, the Coast Guard, the Coast and Geodetic Survey, and the Public Health Service to his new station for the wife and dependent child or children: *Provided*, That for persons in the naval service the term "permanent station," as used in this section, shall be interpreted to mean a shore station or the home yard of the vessel to which the person concerned may be ordered; and a duly authorized change in home yard or home port of such vessel shall be deemed a change of station: *Provided further*, That if the cost of such transportation exceeds that for transportation from the old to the new station the excess cost shall be paid to the United States by the officer concerned: *Provided further*, That transportation supplied the wife or dependent child or children of such officer, to or from stations beyond the continental limits of the United States, shall not be other than by Government transport, if such transportation is available: *And provided further*, That the personnel of the Navy shall have the benefit of all existing laws applying to the Army and the Marine Corps for the transportation of household effects.

1920—Act of June 4, 1920. (41 Stat. L., 812, 825)—An Act Making appropriations for the naval service for the fiscal year ending June 30, 1921, and for other purposes.

[SEC. 1.] . . . That the Superintendent of the Coast and Geodetic Survey shall have the relative rank, pay, and allowances of a captain in the Navy, and that hereafter he shall be appointed by the President, by and with the advice and consent of the Senate, from the list of commissioned officers of the Coast and Geodetic Survey not below the rank of commander for a term of four years, and may be reappointed for further periods of four years each.

1920—Act of June 5, 1920 (41 Stat. L., 874, 929, 930)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1921, and for other purposes.

[SEC. 1.] . . . That the title of "superintendent" of the United States Coast and Geodetic Survey is hereby changed to "director," but this change shall not affect the status of the present incumbent or require his reappointment: *Provided further*, That the Secretary of Commerce may

designate one of the hydrographic and geodetic engineers to act as assistant director.

* * * *

The Secretary of Commerce is authorized to transfer, under such rules and regulations as he may deem advisable, to educational institutions and to museums, such instruments of the United States Coast and Geodetic Survey as, in his judgment, are of historical value but of no further use in the work of that survey, except such historical instruments as may be needed by the Smithsonian Institution for exhibit at the National Museum.

1920—Act of June 5, 1920 (41 Stat. L., 1054)—An Act Authorizing the Superintendent of the Coast and Geodetic Survey, subject to the approval of the Secretary of Commerce, to consider, ascertain, adjust, and determine claims for damages occasioned by acts for which said survey is responsible in certain cases.

That the Superintendent [Director] of the Coast and Geodetic Survey, subject to the approval of the Secretary of Commerce, is hereby authorized to consider, ascertain, adjust, and determine all claims for damages, where the amount of the claim does not exceed \$500, hereafter occasioned by acts for which the Coast and Geodetic Survey shall be found to be responsible, and report the amounts so ascertained and determined to be due the claimants to Congress at each session thereof through the Treasury Department for payment as legal claims out of appropriations that may be made by Congress therefor.

1922—Act of March 28, 1922 (42 Stat. L., 470, 480)—An Act Making appropriations for the Departments of Commerce and Labor for the fiscal year ending June 30, 1923, and for other purposes.

* * * *

Coast and Geodetic Survey for every expenditure requisite for and incident to the work of the Coast and Geodetic Survey, including maintenance, repair or operation of motor-propelled or horsedrawn vehicles for use in field work, and for the purchase of surveying instruments, including extra compensation at not to exceed \$1 per day for each station to employees of the Lighthouse Service while observing tides or currents, and including compensation, not otherwise appropriated for, of persons employed in the field work, and commutation to officers of the field force while on field duty, at a rate not exceeding \$3 per day each, to be expended in accordance with the regulations relating to the Coast and Geodetic Survey prescribed by the Secretary of Commerce, and under the following heads:

Field Expenses, Atlantic Coast: For surveys and necessary resurveys of the Atlantic and Gulf coasts of the United States, including the coasts of outlying islands under the jurisdiction of the United States: *Provided*, That not more than \$45,000 of this amount shall be expended on the coasts

of said outlying islands, and the Atlantic entrance to the Panama Canal, \$138,000;

Pacific Coast: For surveys and necessary resurveys of coasts on the Pacific Ocean under the jurisdiction of the United States, \$314,309.

Tide currents and so forth: For continuing researches in physical hydrography, relating to harbors and bars, and for tidal and current observations on the coasts of the United States, or other coasts under the jurisdiction of the United States, \$29,841.

Coast Pilot: For compilation of the Coast Pilot, including the employment of such pilots and nautical experts in the field and office as may be necessary for the same, \$5,600;

For continuing magnetic observations and to establish meridian lines in connection therewith in all parts of the United States; magnetic observations in other regions under the jurisdiction of the United States; purchase of additional magnetic instruments; lease of sites where necessary and erection of temporary magnetic buildings; continuing the line of exact levels between the Atlantic, Pacific, and Gulf coasts; establishing lines of exact levels in Alaska; determination of geographical positions, by triangulation or traverse for the control of federal, state, boundary, and other surveys and engineering works in all parts of the interior of the United States and Alaska; determination of field astronomic positions; for continuing gravity observations; and including the employment in the field and office of such magnetic observers, at salaries not exceeding \$2,200 per annum, as may be necessary, \$134,560;

For executing precise triangulation and leveling in regions subject to earthquakes, \$15,000;

For special surveys that may be required by the Bureau of Lighthouses or other proper authority, and contingent expenses incident thereto, \$4,550;

For objects not hereinbefore named that may be deemed urgent, including the preparation or purchase of plans and specifications of vessels and the employment of such hull draftsmen in the field and office as may be necessary for the same; the reimbursement, under rules prescribed by the Secretary of Commerce, of officers of the Coast and Geodetic Survey for food, clothing, medicines, and other supplies furnished for the temporary relief of distressed persons in remote localities and to shipwrecked persons temporarily provided for by them, not to exceed a total of \$550; actual necessary expenses of officers of the field force temporarily ordered to the office in the District of Columbia for consultation with the director, and not exceeding \$500 for the expenses of the attendance of representatives of the Coast and Geodetic Survey who may be designated as delegates from the United States at the meetings of the International Research Council or of its branches, \$5,000;

In all, field expenses, \$646,860;

Vessels: For repairs and maintenance of the complement of vessels, including traveling expenses of persons inspecting the repairs, and exclusive of engineer's supplies and other ship chandlery, \$75,000;

For all necessary employees to man and equip the vessels, including professional seamen serving as mates on vessels of the survey, to execute the work of the survey herein provided for and authorized by law, \$528,000.

Pay, commissioned officers: For pay and allowances prescribed by law for commissioned officers on sea duty and other duty, holding relative rank with officers of the navy, including one director with relative rank of

captain, two hydrographic and geodetic engineers with relative rank of captain, seven hydrographic and geodetic engineers with relative rank of commander, nine hydrographic and geodetic engineers with relative rank of lieutenant commander, thirty-eight hydrographic and geodetic engineers with relative rank of lieutenant, fifty-five junior hydrographic and geodetic engineers with relative rank of lieutenant (junior grade), twenty-nine aids with relative rank of ensign, and including officers retired in accordance with existing law, \$524,005: *Provided*, That the Secretary of Commerce may designate one of the hydrographic and geodetic engineers to act as assistant director.

Office force: Disbursing agent, \$3,000; chief clerk, \$2,500; chief of section of library and archives, \$1,800; clerk to director, \$1,800; chief of printing and sales, \$2,000; clerks—three at \$1,800 each, three at \$1,650 each, four at \$1,400 each, eleven at \$1,200 each, fifteen at \$1,000 each, three at \$900 each;

Topographic and hydrographic draftsmen: Two at \$2,900 each, three at \$2,460 each, six at \$2,260 each, six at \$2,060 each; three at \$1,800 each, six at \$1,600 each, six at \$1,400 each; two at \$1,200 each, two copyist draftsmen at \$1,200 each;

Astronomical, geodetic, tidal, and miscellaneous computers: One \$3,000, three at \$2,460 each, two at \$2,360 each, three at \$2,260 each, four at \$2,060 each, four at \$1,800 each, six at \$1,600 each, eleven at \$1,400 each;

Copperplate engravers: One \$2,500, two at \$2,400 each, and three at \$2,200 each, three at \$2,000 each, two at \$1,800 each, two at \$1,600 each, three at \$1,400 each;

Engravers and apprentices at not exceeding \$1,000 each, \$2,000;

Instrument makers: Mechanical engineer \$3,000, one \$1,800, one \$1,600, five at \$1,400 each;

Pattern makers and carpenters: Three at \$1,400 each, two carpenters and painters at \$900 each.

Lithographers, lithographic draftsmen, transferers, lithographic pressmen and their helpers, plate printers and their helpers, and other skilled laborers: Two at \$2,200 each, two at \$2,000 each, one \$1,900, one \$1,800, one \$1,600, eight at \$1,400 each, two at \$1,200 each, one \$1,100, five at \$900 each;

Photographers: One \$1,700, one \$1,600, one \$1,200;

Engineer, electricians, dynamo tenders, and electrotypers: One \$1,800, one \$1,400, one \$1,200, four at \$1,080 each;

Watchmen, firemen, messengers, and laborers: Three at \$880 each, six at \$840 each, four at \$820 each, three at \$720 each, four at \$700 each; plumber and steamfitter, \$1,200;

In all, pay of office force, \$303,110.

Office expenses: For purchases of new instruments (except surveying instruments), including their exchange, materials, equipment, and supplies required in the instrument shop, carpenter shop, and drawing division; books, scientific and technical books, journals, books of reference; maps, charts, and subscriptions; copper plates, chart paper, printers' ink, copper, zinc, and chemicals for electrotyping and photographing; engraving, printing, photographing, and electrotyping supplies; photolithographing charts and printing from stone and copper for immediate use; including the employment in the District of Columbia of such personal services, other than clerical, as may be necessary for the prompt preparation of charts, not to exceed \$7,000; stationery for office and field parties; transportation

of instruments and supplies when not charged to party expenses; office wagon and horses or automobile truck; heating, lighting, and power; telephones, including operation of switchboard; telegrams, ice, and washing; office furniture, repairs, traveling expenses of officers and others employed in the office sent on special duty in the service of the office; miscellaneous expenses, contingencies of all kinds, and not exceeding \$4,000 for extra labor, \$100,000.

Appropriations herein made for the Coast and Geodetic Survey shall not be available for allowance to civilian or other officers for subsistence while on duty at Washington (except as hereinbefore provided for officers of the field force ordered to Washington for short periods for consultation with the director), except as now provided by law.

Total, Coast and Geodetic Survey, \$2,176,975.

APPENDIX 5

FINANCIAL STATEMENT

EXPLANATORY NOTE

Statements showing appropriations, receipts, expenditures, and other financial data for a series of years constitute the most effective single means of exhibiting the growth and development of a service. Due to the fact that Congress has adopted no uniform plan of appropriations for the several services and that the latter employ no uniform plan in respect to the recording and reporting of their receipts and expenditures, it is impossible to present data of this character according to any standard scheme of presentation. In the case of some services the administrative reports contain tables showing financial conditions and operations of the service in considerable detail; in others financial data are almost wholly lacking. Careful study has in all cases been made of such data as are available, and the effort has been made to present the results in such a form as will exhibit the financial operations of the services in the most effective way that circumstances permit.

The Coast and Geodetic Survey receives annual appropriations from Congress and in addition benefits from the appropriations for "Printing and Binding" and "Contingent Expenses," made to the Department of Commerce. The statements which follow show only the appropriation made directly to the service. The appropriations include all deficiency amounts with the exception of "auditors certified claims." These are usually small and in most cases arise as the result of the lapsing of an appropriation. The expenditures in the following table, unless otherwise noted, are figured on the accrual basis. They represent, therefore, the total amount expended out of an appropriation, regardless of whether the disbursements were made during the current fiscal year for which the appropriation was made or during the two succeeding years in which the money was available.

FINANCIAL STATEMENT

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COAST AND GEODETIC SURVEY APPROPRIATIONS AND EXPENDITURES: FISCAL YEAR 1880; BY FIVE-YEAR INTERVALS TO 1910 AND ANNUALLY 1911 TO 1923, INCLUSIVE

Object	1880		1885		1890		1895	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries	^a \$495,000.00	^a \$494,125.70	\$254,370.00	\$252,093.11	\$252,205.00	\$238,196.21	\$236,956.40	\$228,885.52
Pay, etc., officers and men on vessels.	.....	.....	.....	.....	.....	.....	.....	.....
Party expenses	(b)	(b)	154,600.00	130,188.05	161,700.00	156,289.94	147,800.00	105,768.82
Repair of vessels	40,000.00	40,000.00	42,000.00	40,939.66	28,000.00	28,062.68	25,000.00	24,348.91
General expenses	^c \$38,000.00	^c \$38,000.00	^d 103,091.42	^d 104,201.20	^e 78,760.00	^e 62,081.13	^e 36,500.00	^e 23,991.93
Salaries, etc., weights and measures.	7,000.00	7,000.00	6,978.50	6,836.62	4,570.00	4,322.82	5,165.00	5,108.44
National security and defense fund.	.....	.....	.....	.....	.....	.....	.....	.....
Increased compensation ..	.....	.....	.....	.....	.....	.....	.....	.....
Miscellaneous .....	.....	.....	.....	.....	.....	.....	.....	.....
Total	\$580,000.00	\$579,125.70	\$561,039.92	\$534,258.64	\$525,235.00	\$488,862.78	\$451,421.40	\$388,103.62

Object	1900		1905		1910		1911	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries	\$250,150.00	\$245,416.95	\$293,380.00	\$284,184.46	\$335,890.00	\$326,960.81	\$341,390.00	\$335,977.22
Pay, etc., officers and men on vessels.	.....	.....	210,245.00	202,343.82	245,000.00	228,274.85	245,000.00	239,724.19
Party expenses	231,593.00	176,465.91	^f 264,500.00	237,309.76	326,400.00	305,258.85	320,400.00	301,384.30
Repair of vessels	44,600.00	44,543.49	43,544.79	41,340.34	40,000.00	39,810.15	40,000.00	39,118.28
General expenses	^c \$33,000.00	^c \$32,888.98	^e 51,500.00	^e 50,208.78	50,000.00	49,540.66	50,000.00	49,546.94
Salaries, etc., weights and measures.	10,885.00	9,182.42	.....	.....	.....	.....	.....	.....
National security and defense fund.	.....	.....	.....	.....	.....	.....	.....	.....
Increased compensation ..	.....	.....	.....	.....	.....	.....	.....	.....
Miscellaneous .....	.....	.....	.....	.....	.....	.....	.....	.....
Total	\$570,223.00	\$508,497.75	\$863,169.79	\$815,387.16	\$997,290.00	\$949,845.32	\$996,799.00	\$965,750.93

^a Includes party expenses. ^b Included under salaries. ^c Includes publication of observations.
^d Includes publication of observations, furnishing parts for state surveys and transcontinental geodetic work.
^e Includes publication of observations and Alaska boundary survey. ^f Of this amount, \$189,500 was made available in 1904.

APPROPRIATIONS AND EXPENDITURES: FISCAL YEAR 1880; BY FIVE-YEAR INTERVALS TO 1910 AND ANNUALLY
1911 TO 1923, INCLUSIVE—Continued

Object	1912		1913		1914		1915	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries	\$352,720.00	\$348,244.53	\$353,320.00	\$347,187.14	\$359,320.00	\$355,812.97	\$364,178.34	\$362,173.22
Pay, etc., officers and men on vessels.	245,000.00	222,552.58	245,000.00	240,135.84	252,200.00	250,081.30	252,200.00	250,204.84
Party expenses	317,400.00	299,033.44	314,400.00	307,990.92	320,400.00	310,712.48	370,400.00	368,157.40
Repair of vessels	40,000.00	39,079.50	49,000.00	47,490.50	40,000.00	34,303.34	40,000.00	37,814.72
General expenses	50,000.00	49,497.41	50,000.00	49,548.82	52,500.00	52,208.93	50,000.00	49,462.17
Salaries, etc., weights and measures.	.....	.....	.....	.....	.....	.....	.....	.....
National security and defense fund.	.....	.....	.....	.....	.....	.....	.....	.....
Increased compensation ...	.....	.....	.....	.....	.....	.....	.....	.....
Miscellaneous .....	.....	.....	20,000.00	19,711.84	.....	.....	12,500.00	12,448.34
Total	\$1,005,120.00	\$958,407.46	\$1,031,720.00	\$1,012,065.11	\$1,024,420.00	\$1,003,119.02	\$1,089,278.34	\$1,080,260.69

Object	1916		1917		1918		1919	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries	\$379,020.00	\$376,783.18	\$398,320.00	\$393,123.14	\$449,310.00	\$350,478.02	\$477,360.00	\$377,837.82
Pay, etc., officers and men on vessels.	252,200.00	242,198.54	285,000.00	260,678.12	320,000.00	182,600.48	225,000.00	156,238.47
Party expenses	305,400.00	302,976.19	425,320.00	412,374.96	487,600.00	352,489.19	382,600.00	351,123.98
Repair of vessels	40,000.00	39,638.86	59,000.00	57,205.05	56,000.00	34,823.47	36,000.00	33,868.14
General expenses	50,000.00	49,779.65	68,597.00	67,949.89	102,850.00	101,324.81	81,500.00	78,308.80
Salaries, etc., weights and measures.	.....	.....	.....	.....	.....	.....	.....	.....
National security and defense fund.	.....	.....	.....	.....	105,000.00	h95,686.68	43,250.00	h44,319.71
Increased compensation ...	428,000.00	428,544.61	.....	.....	29,246.51	29,246.51	36,177.48	36,177.48
Miscellaneous	15,000.00	13,335.20	835,000.00	834,416.25	.....	.....	112,500.00	161,609.59
Total	\$1,320,620.00	\$1,303,256.23	\$1,278,593.00	\$1,232,477.38	\$1,550,006.51	\$1,146,449.16	\$1,444,387.48	\$1,189,058.15

^a Repair to steamer "Pathfinder" (without year).

^b A deduction of \$441.66 was made from an appropriation of \$320,400.00 under a joint resolution.

^c Building.

^d Two new vessels, including equipment (without year).

^e Outfitting steamer "Surveyor."

^f Repairs to steamer "Explorer."

^g Charts (appropriated for 1917 and 1918).

^h Figured on cash basis.

ⁱ Alterations to vessels transferred from Navy Department.

APPROPRIATIONS AND EXPENDITURES: FISCAL YEAR 1880; BY FIVE-YEAR INTERVALS TO 1910 AND ANNUALLY
1911 TO 1923, INCLUSIVE—*Continued*

Object	1920		1921		1922		1923	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries	\$571,400.03	\$511,266.75	b \$819,067.00	b \$698,448.56	\$830,110.00	\$744,947.40	\$827,115.00	.....
Pay, etc., officers and men on vessels.	528,000.00	472,154.28	528,000.00	385,813.08	528,000.00	405,000.00	528,000.00	.....
Party expenses	635,700.00	596,700.81	c 524,280.00	a 514,055.98	524,280.00	417,007.24	646,860.00	.....
Repair of vessels	78,370.00	73,066.60	64,000.00	53,425.22	75,000.00	66,911.21	75,000.00	.....
General expenses	102,900.00	102,046.26	116,500.00	115,609.80	100,000.00	85,050.23	100,000.00	.....
Salaries, etc., weights and measures.	.....	.....	.....	.....	.....	.....	.....	.....
National security and defense fund.	.....	3,365.00	.....	.....	.....	.....	.....	.....
Increased compensation ...	154,228.34	154,228.34	142,230.86	142,230.86	146,788.37	146,788.37	.....	.....
Miscellaneous	e 20,500.00	e 20,465.61	e 14,600.00	e 13,855.60	e 72,300.00	50,000.00	.....	.....
Total	\$2,071,098.37	\$1,933,293.65	\$2,208,677.86	\$1,923,439.10	\$2,276,478.37	\$1,915,704.45	\$2,176,975.00	.....

^a These are not total expenditures as liabilities incurred during the fiscal year may be paid during the succeeding two years.

^b Not including \$400 transferred from War Department of which \$393.34 was expended.

^c Not including \$3,156.00 and \$2000 transferred from Geological Survey.

^d Not including \$1,991.86 expended out of \$2000 transferred from Geological Survey.

^e Alterations to vessels transferred from Navy Department.

APPENDIX 6

BIBLIOGRAPHY¹

EXPLANATORY NOTE

The bibliographies appended to the several monographs aim to list only those works which deal directly with the services to which they relate, their history, activities, organization, methods of business, problems, etc. They are intended primarily to meet the needs of those persons who desire to make a further study of the services from an administrative standpoint. They thus do not include the titles of publications of the services themselves, except in so far as they treat of the services, their work and problems. Nor do they include books or articles dealing merely with technical features other than administrative of the work of the services. In a few cases explanatory notes have been appended where it was thought they would aid in making known the character or value of the publication to which they relate.

After the completion of the series the bibliographies may be assembled and separately published as a bibliography of the Administrative Branch of the national government.

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